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John M. Clarke, *Director*

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BY

RUDOLF RUEDEMANN

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INTRODUCTION

The Silurian (Ontarian) fauna of New York was first made known to science in Hall's monumental Palaeontology of New York, where it comprises volume II and part of volume III. It has for a long time been recognized by students of Paleozoic fossils that a revision of volume II which appeared in 1852, or rather of the Silurian fauna of New York, is urgently needed.

The printing conditions at the present time do not encourage an undertaking of that scope; moreover large portions of the Silurian fauna have been dealt with in more recent publications. The more important of these are the monographs of the Guelph fauna and of the eurypterids by Clarke and Ruedemann and of the bryozoans of the Rochester shale by Doctor Bassler.

Large groups of our Silurian fossils are, however, still awaiting monographic treatment. Meanwhile, it seems desirable to publish new faunules that are discovered and use the occasion to revise the related longer known forms.

This bulletin is written mainly for the purpose of making known two faunules of the New York Silurian because of their important geologic bearing. One is the fauna of the Bertie waterlime at Buffalo, N. Y. The other is a large, mainly graptolitic fauna of a shaly channel in the Lockport limestone at Gasport, N. Y. Both of these remarkable faunas, replete with strange and uncommon types of forms, we owe to the untiring enthusiasm and industry of E. Reinhard of Buffalo, who has succeeded in increasing the number of known Bertie waterlime forms from the nineteen which Doctor O'Connell has cited in 1916 to forty-four, thus more than doubling a fauna in

apparently barren and forbidding beds that had been searched for more than 70 years.

Equally interesting and novel is the faunule of the Gasport argillaceous channel that differs entirely from that of the surrounding Lockport limestone, a coral facies in that neighborhood.

There are described here also a number of new or little known species from the Cataract formation, Pittsford shale, Camillus shale, Rochester shale and Cobleskill limestone, and the occasion has been used to discuss a fossil of the Manitoulin limestone (Leveillites hartnageli Foerste) and to describe a new crustacean from the Kokomo limestone of Indiana.

Winifred Goldring has supplied a note on Hostimella.

We are sincerely grateful for the loan of material from the Bertie waterlime and Lockport limestone by Dr F. A. Bather, Dr R. S. Bassler, W. L. Bryant and Dr E. M. Kindle.

The photographs were carefully made by Messrs Edwin Stein and Erwin Pohl, the drawings by Mrs E. K. Bender and the author, all the outlines being obtained by the latter by means of a Leitz macroscopic drawing apparatus. The graptolites were photographed and drawn in with India ink on blue prints by the author.

THE GASPORT "CHANNEL" OF THE LOCKPORT LIMESTONE

In 1923, when the writer saw the Gasport shaly channel in the large quarry of the Wickwire Steel Co. at Gasport, N. Y., it consisted of a plano-convex body of shale, about 210 feet wide and about 15 feet deep in the center (see text figure 1). While it appears semilenticular in section, it probably is elongate, representing the filling of a depression or lagoon. It is intercalated in Lockport limestone beds, being underlain by dense, barren dolomite and overlain by Lockport limestone at the edge of the quarry. Laterally it passes with a jagged margin of interlocking layers into coralline and crinoidal beds of Lockport limestone and, therefore, represents an original depression between the reefs. These horizontally contiguous beds are full of stocks of Favosites, Syringophyllum etc., some of the stocks projecting into the channel. The channel rock itself, for the most part, consists of calcareous and argillaceous shale, sandy near the top and containing six thin layers of shaly limestone. By its dark brown color it contrasts strikingly with the light buff Lockport limestone.

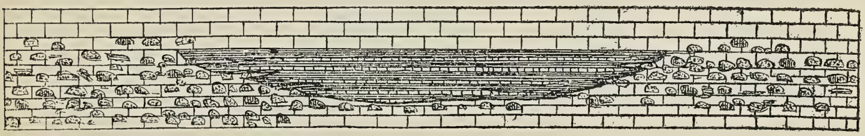

Figure 1 East-west section through Gasport lens or channel.

Our collection of fossils from the "channel" consists of the following species:

Chondrites verus *Rued.*
Ascograptus similis *Rued.*
Callograptus *cf.* minutus altus *Gurley*
Inocaulis plumulosus *Hall*
In. ramulosus *Spencer*
Desmograptus micronematodes (*Spencer*)
Dictyonema retiforme *Hall*
D. infundibuliforme *Rued.*
D. expansum *Spencer*
D. filiramus *Gurley*
D. crassibasale *Gurley*
D. tenellum *Spencer*
Acanthograptus walkeri (*Spencer*)
Calyptograptus cyathiformis *Spencer*
Diplospirograptus goldringae *Rued.*

Medusaegraptus mirabilis *Rued.*
Lingula lamellata *Hall*
Trematis spinosa *Rued.*
Tentaculites *sp.*
Conularia niagarensis *Hall*
C. tenuicosta *Rued.*
Protoscolex batheri *Rued.*
Dactylethra conspicua *Rued.*

The contrast between this fauna and that of the adjoining coralline Lockport limestone is as great as it possibly could be. In species and especially in number of individuals the fauna of the channel is overwhelmingly a dendroid graptolite fauna, while that of the neighboring facies is one of corals, crinoids, brachiopods, trilobites etc. It thus appears that in the channel there existed life conditions totally different from those of the enclosing coral reefs. The mud content of the channel beds indicates that the mud swept along in the channel prevented the growth of the corals, but made a favorable bottom for the dendroid graptolites, all of which were anchored in the mud, either by long tap roots or by disks. A majority of the forms are identical with species described by Spencer and Gurley from the shaly Lockport beds at Hamilton, Ontario. Besides these there also occur Inocaulis plumulosus and Dictyonema retiforme both of which are Rochester shale fossils that extend, as rare occurrences, into the Lockport limestone.

The most important members of the graptolite fauna of the Gasport channel are, however, Diplospirograptus goldringae[1] and Medusaegraptus mirabilis, both of which are common in the channel beds and so novel in structure that they represent new genera that are widely different from the other Dendroidea. The same is true of Ascograptus similis which, however, is a rarer form.

It is thus apparent that the Gasport channel represents a facies that is widely different from that seen in the closely adjacent Lockport limestone and that supported a peculiar fauna of its own, largely composed of Dendroidea.

THE BERTIE WATERLIME FAUNA

The fauna of the Bertie waterlime derives its interest and importance from its prevailing eurypterid content and the discussions that have arisen as to the habitat of the eurypterids.

[1] Diplospirograptus, with its spiral axes, is according to Professor O. Abel, who was shown the material, a distinct adaptation to running water or to strong currents such as probably existed at times in the Gasport channel.

Doctor O'Connell (1916, p. 87) has cited the following faunas from the Bertie waterlime, differentiating the western or Erie district from the eastern or Herkimer district.

(*a*) Bertie fauna of Erie district:

Eurypterids

Dolichopterus macrochirus
D. siluriceps
Eurypterus lacustris
E. lacustris *var.* pachychirus
E. pustulosus
Eusarcus scorpionis
Pterygotus buffaloensis
P. cobbi
P. grandis

Associated forms

Cephalopods — Orthoceras undulatum
Trochoceras gebhardi
Brachiopod — Lingula *sp.*
Ostracod — Leperditia alta
Pelecypod — Goniophora *sp.*
Pulmonate Gastropods — Hercynella buffaloensis
H. patelliformis
Graptolites — "Buthotrephis lesquereuxi" (formerly considered seaweed, now identified by Ruedemann as graptolites)
Ceratiocarid — Ceratiocaris acuminata
Plant — Chondrites graminiformis (may be a graptolite)

(*b*) Bertie fauna of Herkimer district:

Eurypterids

Dolichopterus macrochirus
D. testudineus
Eurypterus remipes
Pterygotus macrophthalmus
P. cobbi

Associated forms — Scorpion
Proscorpius osborni

This list has been materially changed in its aspect by the more recent collections of Mr Reinhard and others. It reads now (new forms marked by asterisk):

(*a*) Bertie fauna and flora of Erie district:

Eurypterids, same as above in O'Connell's list

Associated forms

Plants

Algae

*Calithamnopsis silurica *Rued.*
*Morania (?) bertiensis *Rued.*
*Sphenophycus (?) *spec.*

Corals
*Stromatopora *sp.*
*Ceratopora (?) *sp.*

Graptolites
Inocaulis lesquereuxi (*Grote and Pitt*)
*Palaeodictyota buffaloensis *Rued.*
Medusaegraptus graminiformis (*Pohlman*)
*Orthograptus (?) *sp.*
*Climacograptus ultimus *Rued.*

Cystids
*Pyrgocystis batheri *Rued.*

Bryozoans
*Stigmatella *sp.*

Brachiopods
*Lingula media *Rued.*
*Orbiculoidea bertiensis *Rued.*
Camarotoechia *cf.* andrewsi *Prouty*
*Spirifer (Delthyris) eriensis (*Grabau*)

Vermes
*Bertiella obesa *Rued.*
*Serpulites *sp.*

Mollusca

Lamellibranchs
*Rhytimya buffaloensis *Rued.*
Goniophora *sp.*

Gastropods
Hercynella buffaloensis *O'Connell*
H. patelliformis *O'Connell*
*Loxonema bertiense *Rued.*
*Hormotoma gregaria *Rued.*

Conularidae
*Conularia perglabra *Rued.*

Cephalopods
*Orthoceras *sp.*
Dawsonoceras oconnellae *Rued.*
Trochoceras *cf.* anderdonense *Grabau*
*Pristeroceras timidum *Rued.*

Crustaceans
Ceratiocaris acuminata *Hall*
C. maccoyana *Hall*
*Lepidocoleus reinhardi *Rued.*
*Emmelezoe minuta *Rued.*
Leperditia alta (*Conrad*)
L. scalaris (*Jones*)

Merostomes
*Bunaia woodwardi *Clarke*
*Hemiaspis (?) eriensis *Clarke*

(*b*) Bertie fauna of middle and eastern districts:

Eurypterids

Dolichopterus macrochirus *Hall*
D. testudineus *Clarke* and *Ruedemann*
Eurypterus remipes *Dekay*
Pterygotus macrophthalmus *Hall*
P. cobbi *Hall*
*Eusarcus trigonus *Rued.*

Associated forms

*Lingula subtrigona *Rued.*
*L. testatrix *Rued.*
*Orthoceras vicinus *Rued.*
*Phragmoceras accola *Rued.*
*Pseudoniscus clarkei *Rued.*
Proscorpius osborni *Whitfield*

A comparison of the two lists shows that the additions are all in the associated forms, that they consist of seaweeds, corals, graptolites, cystids, bryozoans, brachiopods, lamellibranchs, gastropods, cephalopods and crustaceans, or in other words, of marine fossils.

This is an important fact in view of the hypothesis advanced by Doctor O'Connell (1916, p. 106–18) that "where the Bertie is eurypterid-bearing, the rock was evidently deposited above sea level, as a river flood plain and subaerial delta deposit." Two rivers are assumed to have come to the sea from the north, one each for the eastern and western eurypterid faunas or "pools," and they are believed to have derived the calcareous mud that formed the Bertie waterlime and dolomite from the exposures of Niagaran and Trenton limestones.

We do not intend here to enter into a lengthy discussion of this elaborately worked out, genial hypothesis which is a corollary of the view that the eurypterids were denizens of the rivers; but wish merely to point out a few facts that can not be readily reconciled with this hypothesis.

The first fact is the large content of marine fossils in the Bertie waterlime, hitherto not observed. The list comprises forms of all classes of marine animals, observed in Silurian faunas. It could therefore be concluded that the Bertie waterlime actually contained a typical marine fauna. This is, however, not the case, for the majority of the new forms cited have been found only in few examples, and might therefore be well considered as stragglers carried into the delta during severe storms. This is in part supported by the fact that many of the shells, especially the molluscs, are poorly preserved. They are reduced to a mere film. This, however, is also the case with the shells of Hormotoma gregaria which are found

in great numbers on some surfaces, and of Pristeroceras timidum, of which also a considerable number of specimens were obtained. The shadowy preservation of fossils on some of the slabs seems to us more to be attributed to an early and complete dissolution of the aragonitic shells in the dolomite mud, than to their long drifting about. Indeed, we are convinced that the scarcity of marine shells in the Bertie waterlime is largely due to their early complete dissolution.[1]

On the other hand, the more resistant chitinous tests of the graptolites and brachiopods are found in dense swarms on some beds. This is especially the case with Inocaulis lesquereuxi, Medusaegraptus graminiformis, Climacograptus ultimus and Lingula media. Climacograptus ultimus might have drifted in during storms, as Grabau assumes for most graptolites in black shales; but Inocaulis lesquereuxi and Medusaegraptus graminiformis are sessile dendroid graptolites which most probably grew near where they are found. This is undoubtedly so in the case of Medusaegraptus graminiformis, the young stages of which are found in upright position in the rock (see plate 8 figure 3). Also perfect colonial stocks of Inocaulis lesquereuxi, as that reproduced in plate 12 figure 2 can not have drifted far but must be *in situ*. Likewise is Lingula media so evenly distributed over the bedding planes that it appears as a native form and not as a straggler washed in and piled up.

We thus see in the new fauna here published fair evidence that the Bertie waterlime is an actual marine deposit.

Another significant fact overlooked by Doctor O'Connell is the gradual gradation of the Bertie waterlime into the overlying "Bull head" (Akron dolomite). Hartnagel has already pointed out (1905, p. 357) that in Ontario county the Bertie waterlime with eurypterids and the Akron dolomite with corals and other marine fossils alternate twice at the boundary. At Buffalo it is difficult to draw the line between the Bertie and Akron formations. The two formations are bound still closer together by the finding of eurypterids

[1] The complete destruction of most fossils with calcareous shells through slow sedimentation and diagenetic processes has been pointed out by various authors (see especially Wepfer 1916) as causing the lack of fossils in limestone and dolomite beds. How complete this process is in the Bertie waterlime is shown by slabs covered with mere carbonaceous shadows of Lingulas, whose phosphatic shells have even been dissolved. Some surfaces (see plate 14, figure 5) are densely crowded with coprolites of unknown animals, no trace of which is left. All these observations testify to an abundance of life in the waters of later Bertie time in spite of the present barrenness of the rock.

(Eurypterus buffaloensis, Pterygotus), an Inocaulis and Medusaegraptus graminiformis in the Akron dolomite, and of the characteristic Akron fossils Spirifer eriensis and Leperditia scalaris (Jones) in the upper Bertie.

Now the Akron dolomite is the western continuation of the Cobleskill limestone, which in the east is a typical coral facies and was originally called the " Coralline limestone." Also the " Bull head " at Buffalo is still replete with specimens of Cyathophyllum hydraulicum.

The close connection of the Coralline limestone with the Bertie suggests the view that the Bertie is a lagoon deposit formed behind coral reefs. The coral reefs during Bertie time were farther south extending from east to west or rather southwest, the coast lying north and the pool running from east to west. This hypothesis would explain a host of facts much more readily than Doctor O'Connell's delta hypothesis; especially the wide horizontal extension and relative thinness of the Bertie waterlime; the presence of " hopper-crystals " (salt skeleton crystals) in the Bertie such as are also found in the Camillus and which indicate a highly saline condition of the water; the appearance of a number of strange fossils, as Calithamnopsis silurica, Inocaulis lesquereuxi, Palaeodictyota buffaloensis, Medusaegraptus graminiformis,[1] Pyrgocystis batheri, Bertiella obesa, the Hercynellas, Trochoceras, Pristeroceras timidum, Lepidocoleus reinhardi, the Ceratiocarids, Emmelezoe minuta, Bunaia woodwardi and Hemiaspis eriensis which point to conditions not normally marine, but well reconcilable with those existing in the broad lagoons behind the reefs. Considering that the Bertie is underlain by the barren Camillus shale, denoting salt pan conditions and overlain by the marine Akron dolomite, it follows that a sinking of the land with resulting gradual invasion of the sea from the south is to be inferred. It is significant in this connection that all the fossils of the Bertie, inclusive of the eurypterids, are found, according to Mr Reinhard, in the uppermost Bertie beds, where the purely marine conditions of the Cobleskill were approached. The presence of marine conditions indicating open sea at the same time in the south and southwest (Pennsylvania, Maryland and West Virginia) is brought out by the work of Swartz (1923, p. 40–50) in Maryland.

[1] It is here worth while pointing out that the only other Medusaegraptus so far known, namely, M. mirabilis Rued. occurs in the Gasport channel close to the Lockport coral reefs.

It is impossible to say which of the Bertie fossils could have been fresh water animals that were carried out to sea. The Hercynellas which were considered so by Doctor O'Connell are certainly marine (see postea p. 52). This leaves the plants, crustaceans, merostomes and the scorpion.

The status of the problem of the habitat of the eurypterids has been recently discussed by the writer (1924, p. 227) from the investigations of Versluys and Demoll. It appears from their thorough anatomic studies that the merostomes were probably derived from primitive scorpionlike ancestors that entered the sea from the land.

The finding of groups of eurypterid brood, like that reproduced in plate 24, figure 5, refutes the assertion of Grabau and O'Connell that the eurypterid remains were carried out to sea by the rivers, for there can not be any doubt that these very minute eurypterids (about 2.5 mm long) obviously very early growth-stages, could not have been transported into the sea single and still less in groups, but obviously were hatched near where they or perhaps their moulted skins were found.

As to the scorpion of the Bertie waterlime, which was considered by Clarke and Ruedemann (1912, p. 387 ff.) as a marine form, but by Pompeckj (1923, p. 331), with the other Silurian scorpions, held to be a land animal, it is pointed out by Abel (1924, p. 125, 126) that absence of stigmata, the blindness of Palaeophonus and the development of the ocelli in Proscorpius, as well as the structure of the legs, leave no doubt that these scorpions were secondarily adapted to water. Since all have been found in marine beds there is no reason to assume that they were fresh water forms.

On the other hand, evidence is accumulating that Limulus originated as a fresh water form (see Kirchner, 1923, p. 639). If the eurypterids as well as Limulus are derived from land animals, as Versluys and Demoll infer, it is quite probable that we have to see in the Xiphosura (Limulus, Belinurus, Prestwichia etc.) that branch of the merostomes that adapted itself to the fresh water and in the Synxiphosura (Aglaspis, Hemiaspis, Bunodes etc.) and in the Eurypterida those branches that adapted themselves to marine conditions. The fossil Xiphosura are practically all undoubted fresh water forms. Limulus is the only exception (but is secondarily marine), while in the Synxiphosura and Eurypterida the weight of the evidence is in favor of marine habitats. Considering that these creatures entered the sea from the land, it is readily understood why they preferred the quiet lagoons behind coral reefs and other barriers.

DESCRIPTIONS OF FOSSILS

I PLANTAE

Callithamnopsis silurica nov.

Plate 4, figure 4

Description. Fragment of thallus observed, consisting of main branch bearing whorls of branchlets at regular intervals, which in turn divide at shorter intervals into whorls of branchlets of a higher order. The nodes are slightly inflated and through their darker color indicate an original thickening of the thallus. The branchlets appear relatively stout and stiff in the basal portions that are preserved. A fragment lying near the specimen may be a part of a branchlet of similar character.

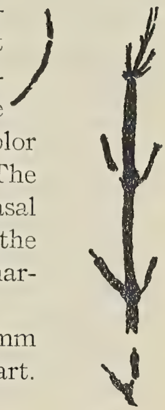

Figure 2. Calithamnopsis silurica Rued. Holotype x3.

Measurements. The fragment is 16 mm long, .5 mm wide and the whorls are, on the main branch, 5 mm apart. The branchlets subdivide 2 mm from the base.

Horizon and locality. Bertie waterlime near Buffalo, on slab with specimens of Hormotoma gregaria Rued.

Remarks. This interesting little alga is the first representative of the genus Callithamnopsis described from the Silurian. The genus is based on forms from the " Trenton " shale of Wisconsin (see Whitfield, 1902, p. 354)[1] and the Glens Falls limestone (basal Trenton) of New York (Ruedemann, 1909). From the earlier species the Silurian form is readily distinguished by the greater distance between the whorls of branchlets on the main branch and the shorter " internodes " of the branchlets. The Mohawkian species are marine and the same is probably true of the Silurian form.

Chondrites verus nov.

Plate 4, figure 5

The genus Chondrites of fossil " algae " has been under a cloud for many years, partly because, as in Fucoides, Caulerpites and others, the name has been applied to indefinite and indistinct surface markings which happen to resemble in shape certain of the better known genera of recent seaweeds (Seward, 1898, p. 142), and partly since

[1] The locality is Platteville, Wis., and the horizon probably the Upper Platteville limestone, which is of early Black River age.

Nathorst has shown that many of the species of Chondrites, Cruziana, Spirophyton, Eophyton etc. are inorganic and animal markings. (*Id.* p. 144).

On the other hand, there are known a number of undoubted algal remains which bear a close resemblance in their habitus to the recent genus Chondrus and other Rhodophyceae, and which, therefore, may be compared with the latter without danger of misleading conclusions. To this undoubted algal remains also belongs the form here reproduced on plate 2, figure 5, as Chondrites verus.

This fossil from the Gasport lens of the Lockport limestone retains a distinct carbonaceous film, leaving no doubt of its organic nature. The principal characters of the thallus are a fairly slender, dichotomously branching stem, originally probably cylindrical and terminating in clusters of ribbonlike expansions of the thallus, produced by dichotomous division. The latter contrast by their apparent flexuous character with the more rigid, erect stems.

The thallus is about 10 cm high, the stem 2 mm wide, the furcations of the stem 3 cm apart; the bandlike expansions are 3–6 cm long and about 3 mm wide.

Morania (?) **bertiensis** nov.

Plate 4, figure 1

The Bertie waterlime at North Buffalo contains nondescript fossils, a representative specimen of which is figured in plate 1, figure 1. This appears as an irregular, subcircular carbonaceous film, slightly lobed along the margin of one side, while that of the other side is continuous and well defined. The carbonaceous film lacks all traces of structure; it is, however, thick enough to indicate the original presence of a substantial amount of organic matter. In the overlying rock three transverse curved ridges are seen, which appear as foldlike projections of the basal film, but are filled with crystalline calcareous matter and may belong to an independent body.

The flat, carbonaceous body could be compared with the mucous, gelatinous or membranaceous tegument forming the sheaths that surround the thallus of the Nostocaceae. There is, of course, no evidence for or against such assumption except the general form and carbonaceous substance of the fossil. Walcott (1919, p. 225) has described and figured a whole series of irregular carbonaceous bodies from the Middle Cambrian of British Columbia, referring them to the Nostocaceae and uniting them under the new genus *Morania*.

We can do no better than refer our fossil to that genus of Cambrian algae.

Sphenophycus (?) sp.

Plate 4, figures 2, 3

In 1912 (p. 74) the writer described as algal flotation appendages club-shaped bodies which have been found associated and in one case attached to remains of Sphenophycus latifolius Hall, in the Schenectady beds (Ordovician) of New York. The remains here figured, especially that represented by figure 2, are very similar to these supposed gas bulbs of Sphenophycus and may therefore be also described as being of the nature of algal flotation appendages.

Hostimella P. & B.

BY WINIFRED GOLDRING

Under this genus have been described plant remains from the Lower Devonian of Röragen, Norway, and the Middle Devonian of Bohemia. These plant remains, first described as seaweeds, are now recognized as of a terrestrial nature (Potonié, H. and Bernard, C., Flore Devonienne de l'etage H de Barrande, p. 18, 1904, in Syst. Silur. du Centre de la Bohême by J. Barrande) though their relationship is not established. Arber (1921, Devonian Floras) refers to the examples of this genus as still entirely obscure objects, appearing to stand nearest to Psilophyton. Two varieties have been described, H. hostimensis P. & B. α) typica, H. hostimensis P. & B. β.) rhodeaeformis.

Hostimella silurica Goldring

Plate 5, figures 1 and 2

This Silurian plant from the Bertie waterlime has been placed in this genus, because, while of obscure nature, it has the general habit of the described species of Hostimella, bearing closer resemblance to the first described type, typica. The dichotomous branching resulting in unequal branches is well shown. The wider branches follow the direction of the main axis and the smaller branches occur on alternate sides, giving the effect of a main stem with alternately arranged branches. The larger of the two specimens figured had a small amount of carbonized tissue still attached, but attempts to find structure gave no results. Pitted vessels and fibres were found by Potonié and Bernard in the Devonian material.

In this connection may be also mentioned a large rootlike plant remains (see plate 16, figure 1) from the Bertie waterlime at Buffalo, now in the Buffalo Museum (No. 13309).

It resembles a large tap root, measuring (incomplete) 395 mm in length, and tapering in that length from 37 mm to a fairly acute extremity. There are no traces of appendages or of bases of such. The fossil consists of a thick layer of anthracite (1 mm thick in parts), which, however, exhibits no traces of whatever structure. It is therefore entirely on the outline and substantial carbon deposit that our reference of this remains to the land plants is based.

There is no evidence on which a reference of this fossil to the seaweed Nematophycus crassus (Penhallow) found in the Akron (Bull head) of North Buffalo could be based.

II GRAPTOLITOIDEA

Ascograptus gen. nov.

(Greek Ascon = tube)

Rhabdosome consisting of axial tube, from which separate conical thecae arise in spiral arrangement.

Genotype. Ascograptus similis nov.

Ascograptus similis nov.

Plate 6, figures 1–8

Description. Axial tube slender (diameter 0.2 mm); cylindrical; thecae elongate conical, to elongate pyriform, about 6 times as long as wide (1.0 to 1.5 mm long and .25 mm wide), numbering 3–15 or more; aperture round, open, somewhat contracted; base of thecae a slender tube.

Horizon and locality. In sandy lens of Lockport limestone at Gasport, N. Y.

Remarks. In seeing these minute radial clusters, one is readily led to refer them to the bryozoan Ascodictyon and to compare them with the A. siluriense Vine, that occurs besides in Great Britain also in the Rochester shale of New York and the Waldron shale of Indiana and Tennessee. On closer study, however, doubts arise as to the correctness of such a reference in spite of the close exterior similarity. Firstly, no connecting hollow threads between the radial clusters of vesicles can be found; it is, however, possible that these might have failed of preservation, if ever present; and it is to be mentioned in this connection that the five more complete specimens here figured were all found on an area of a square inch and therefore might well have all belonged together. But they are not on exactly the same level of the rock and there is nothing to indicate that they were parasitic on any shell, as the zoaria of Ascodictyon always are. They are free on the surface of the rock and moreove the arrangement of the thecae in a radial cluster, open on one side

and rising from one end of the series to the other in the rock leaves hardly any other explanation than that the thecae had a spiral arrangement, on a vertical axis, that in the specimens is seen only in section and that probably stood erect on the muddy bottom of the sea, being anchored by a threadlike root. The straight transverse terminal edges of most of the thecae indicate the presence of a subcircular aperture. In several cases the aperture itself is seen compressed obliquely with what may have been slightly produced opposite lappets of the margin.

The thecae appear as carbonaceous impressions, indicating an originally chitinous substance. Closely arranged, minute pores such as are observable on the vesicles of Ascodictyon, have not been seen, but, on the other hand, no traces of siculae or growth lines have been found. Therefore, while we, on account of the differences from Ascodictyon here noted, do not believe that the organisms can be referred to the bryozoans, there is not sufficient evidence to prove their graptolite nature. They would represent an aberrant primitive group of the Dendroidea, related to Corynoides and preserving in the thecae the original conical form of the sicula.

Acanthograptus walkeri (Spencer)

Specimens of Acanthograptus walkeri have been obtained in the Gasport lens of the Lockport limestone. Two of these have been figured here. Spencer's original material came from the same horizon at Hamilton, Ontario.

The species has also been found in the Rochester shale at Middleport, N. Y., and has been fully described

Fig. 3.

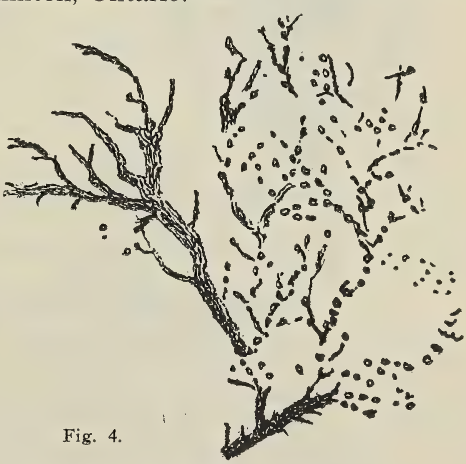

Fig. 4.

Figures 3 and 4 Acanthograptus walkeri Spencer.

Figure 3 Specimen, natural size. Figure 4 Another pyritized specimen, x 3, showing the ropy structure of the stem and the sections of the projecting thecae.

from the collection obtained there by the writer (1908, p. 194). One specimen is pyritized and exhibits beautifully the composition of the entire stem of a ropy mass of twisted tubes and the tubular (circular) sections of the projecting thecae.

Callograptus cf. **minutus altus** Gurley

The specimen before us agrees in its general habit, as well as the dimensions of the branches with the variety altus Gurley (see Bassler, 1909, p. 15) of Spencer's species Callograptus minutus. It is, however, 3 times the size of Gurley's type, a difference which may be attributed to the fact that both Spencer's and Gurley's types were but young individuals. Our specimen measures 19 mm in width and 28 mm in height; the delicate, frequently bifurcating branches are .2 mm wide and separated by intervals of about .5 mm. The thecal apertures do not project and are closely arranged.

Our specimen came from the Gasport lens of the Lockport limestone, Spencer's from the same formation in Ontario, Canada.

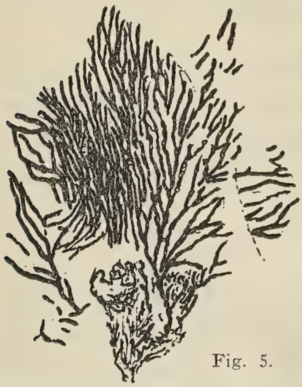
Fig. 5.


Fig. 6.

Figure 5 Callograptus cf. minutus altus Gurley. Natural size.

Figure 6 Calyptograptus cyathiformis Spencer. Natural size.

Calyptograptus cyathiformis Spencer

Calyptograptus cyathiformis Spencer. Canadian Nat., VIII 1878, p. 458, 460; Trans. Acad. Sci. St Louis, IV, 1884, p. 564, 578, pl. 3, fig. 3; Bul. Mus. Univ. State Missouri, I, 1884, p. 28, pl. 3, fig. 3; Miller, North Amer. Geol. and Pal. 1889, p. 175, fig. 145; Gurley, Jour. Geol. 1896, p. 93, 308; Bassler, Bul. U. S. Nat. Mus. 65, 1909, p. 38–39, fig. 48.

A characteristic specimen of this species, hitherto known only from the Lockport limestone at Hamilton, Ontario, has been found in the Gasport lens of the Lockport limestone at Gasport, N. Y. It affords no additional data to Spencer's careful description.

Dendrograptus rectus Ruedemann

A specimen of this beautiful graptolite, described and hitherto known only from the Clinton shale, overlying the lower ore bed (see Ruedemann, 1908, p. 145) has been obtained in the Rochester shale at Lockport, N. Y.

Desmograptus micronematodes (Spencer)

Calyptograptus micronematodes Spencer. Canadian Nat., X, 1882, p. 165, nomen nudum; Trans. Acad. Sci. St Louis, IV, 1884, p. 564, 579, 588, pl. 3, figs. 4, 4a; Bul. Mus. Univ. State Missouri, I, 1884, p. 14, 29, 38, pl. 3, figs. 4, 4a; Bassler, U. S. Nat. Mus. Bul. 65, 1909, p. 39–40, figs. 49, 50; Bassler, U. S. Nat. Mus. Bul. 92, 1915, p. 170.

Calyptograpsus micronematodes Gurley, Jour. Geol. IV, 1896, p. 93, 308.

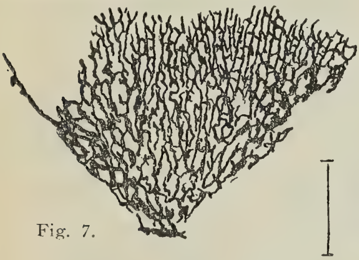

Fig. 7.

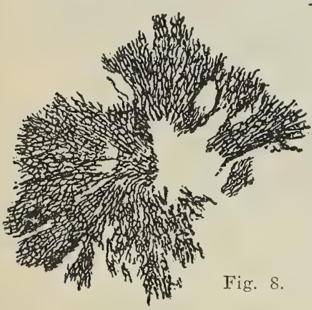

Fig. 8.

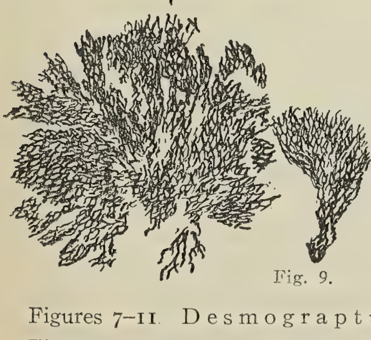

Fig. 9.

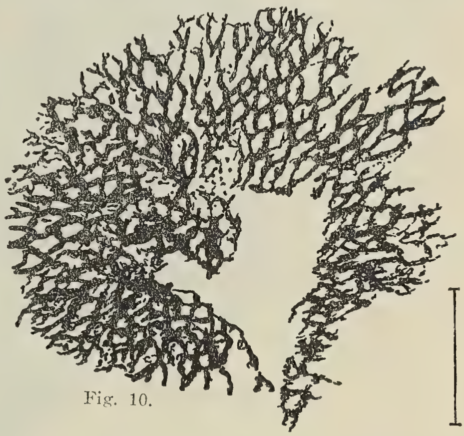

Fig. 10.

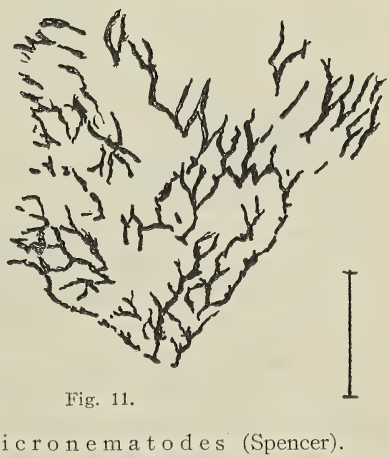

Fig. 11.

Figures 7–11 Desmograptus micronematodes (Spencer).

Figure 7 Specimen exhibiting lateral view and showing flat, disklike base. Figure 8 Top view of flattened specimen. Natural size. Figure 9 Lateral view of specimen. Natural size. Figure 10 Top view of young flattened specimen. Figure 11 Fragmentary rhabdosome with slightly wider meshes, from the Clinton sandstone at Niagara Falls.

Spencer had " only two or three specimens of this beautiful little frond " and Bassler found only a single specimen in the Spencer collection. Spencer had obtained his material near the base of the Niagara dolomite (Lockport limestone) near Hamilton, Ontario. In the Gasport lens of the Lockport limestone at Lockport, N. Y., the delicate little graptolite seems to be a little more common, for we have fourteen specimens at hand from that locality. These permit the following data to be added to Spencer's description:

Rhabdosome broadly cyathiform, growing from a flat basal disk, attaining a width of 45 mm; smooth in the basal part, but later becoming more or less folded. The branches undulating and coming regularly into direct contact with the neighboring branches or connected with them by short thick dissepiments; they form thus in some parts a true Desmograptus, in others approaching the Dictyonema structure. The meshes thus formed are elliptic or biconvex in outline, 1 to 1.5 mm long and .6 mm wide (about 8 in 5 mm); the branches are 2.5 to 3 mm wide. No thecal apertures or projecting thecae (denticles) have been seen.

Although Spencer described this form under his genus Calyptograptus, the structure of the rhabdosome with its undulating, regularly coalescing branches is decidedly that of a Desmograptus and not that of the genotype of Calyptograptus, namely C. cyathiformis.

Dictyonema crassibasale Gurley

Plate 1, figure 1

Dictyonema gracile Spencer (not Hall), Trans. Acad. Sci. St Louis, IV, 1884, p. 573, 574, pl. 2, figs. 2, 3; Bul. Mus. Univ. State Missouri, I, 1884, p. 24, pl. 2, figs. 2, 2*a*, 3; Bassler, U. S. Nat. Mus. Bul. 65, 1909, p. 19–24; figs. 21–25; pl. 3, fig. 1; Bassler, U. S. Nat. Mus. Bul. 92, 1915, p. 422.

Dictyonema crassibasale is the commonest and largest of the Dictyonemas of the wonderful dendroid fauna discovered at Hamilton, Ontario. Gurley (Bassler, 1909, p. 21) reports a specimen, " indicating a diameter for the whole polypary of nearly half a meter." The New York State Museum possesses a perfect specimen from the same locality, here reproduced in plate 1, figure 1, showing a diameter of 10 inches.

This species is also common in the Gasport lens of the Lockport limestone at Lockport. We figure here a specimen in which two portions of the broadly cyathiform rhabdosome overlap in such a way as to suggest that the rhabdosome may have grown upward in a flat spiral. The large specimen here figured indicates a very flat saucer-shaped form of the rhabdosome, with a broadly conical entral portion.

Fig. 12.

Fig. 13.

Figures 12 and 13 D i c t y o n e m a c r a s s i b a s a l e Gurley.

Figure 12 Young specimen; natural size. Figure 13 Basal fragment, showing rows of thecal apertures at the right.

Dictyonema expansum Spencer

Dictyonema expansum Spencer. Acad. Sci. St Louis, IV, 1884, p. 504, 575, 576, pl. 2, fig. 1; Bul. Mus. Univ. State Missouri, I, 1884, p. 14, 25, 26, pl. 2, fig. 1; Gurley, Jour. Geol. IV, 1896, p. 96, 308; Bassler, U. S. Nat. Mus. Bul. 65, 1909, p. 31–34, figs. 36, 37; Bassler, U. S. Nat. Mus. Bul. 92, 1915, p. 423.

The presence, in the Gasport lens of the Lockport limestone at Lockport, N. Y., of this species is indicated by several fragments, one of which is figured here. The species is found in large flabelliform rhabdosomes in the Lockport limestone at Hamilton, Ontario. It is fully described by Gurley (see Bassler, 1909, p. 31).

Fig. 14.

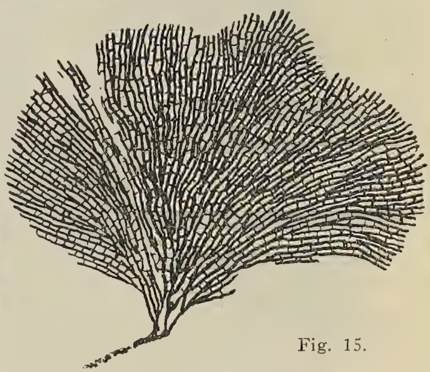

Fig. 15.

Figure 14 Dictyonema expansum Spencer. Fragmentary rhabdosome. Natural size.

Figure 15 Dictyonema filiramus Gurley. Specimen figured in natural size.

Dictyonema filiramus Gurley

Dictyonema filiramus (Gurley *ms.*) Bassler, U. S. Nat. Mus. Bul. 65, 1909, p. 34, fig. 38–40; Bassler, U. S. Nat. Mus. Bul. 92, 1915, p. 423.

This extremely delicate form from the Lockport limestone at Hamilton, Ontario, can be recognized in the fine complete rhabdosome here figured. In dimensions the latter is a little coarser than the Hamilton specimens; the width of the branches being throughout .4 mm and the number of branches hardly more than 35 in 25 mm against the 40 estimated by Gurley.

Dictyonema infundibuliforme nov.

Description. Rhabdosome infundibuliform; in the type specimen 9 cm high and about 11 cm wide at the upper margin; the lateral margins forming approximately a right angle. In another specimen they form only half that angle. The branches are rigid, very straight,

bifurcating at infrequent intervals; throughout .8 mm wide and 1 mm apart; numbering 17 in 25 mm. The dissepiments are thin and are about 5 mm apart; the meshes about 5 times as long as wde. Flat basal disk.

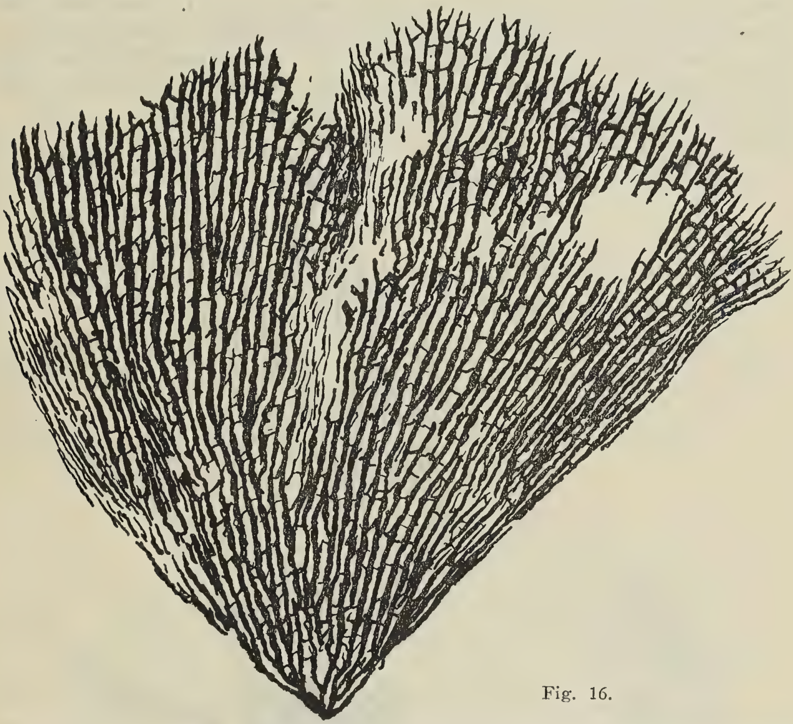

Fig. 16.

Figure 16 Dictyonema infundibuliforme Ruedemann. Holotype, natural size.

Horizon and locality. Gasport lens of Lockport limestone, Lockport, N. Y.

Remarks. This species is closely related in the character of the branches to D. expansum Spencer and D. percrassum Gurley, especially the former. It is readily distinguished from both by its infundibuliform habit of growth.

Dictyonema retiforme Hall

Several fragmentary specimens from the Gasport lens of the Lockport formation are referable to D. retiforme, a species that in New York finds its principal distribution in the Rochester shale (see Hall, 1852, p. 174; Ruedemann, 1908, p. 155). In Ontario it is found in the more shaly dolomites of the Hamilton, Ontario section (Bassler, 1909, p. 19).

Dictyonema tenellum Spencer

Dictyonema tenella Spencer. Canadian Nat., VIII, 1878, p. 458, 459.

Dictyonema tenellum Spencer. Canadian Nat. X, 1882, p. 165; Trans. Acad. Sci. St Louis, IV, p. 564, 576, (not pl. 1, fig. 13); Bul. Mus. Univ. State Missouri, I, p. 14, 26 (not pl. 1, fig. 13); Miller, North Amer. Geol. & Pal., 1889, p. 185; Gurley, Jour. Geol. IV, 1896, p. 96, 308; Bassler, U. S. Geol. Surv. Bul. 65, 1909, p. 28–30, pl. 2, fig. 4, figs. 32, 33; Bassler, U. S. Geol. Surv. Bul. 92, 1915, p. 427.

Fig. 17.

Fig. 18.

Figures 17 and 18 Dictyonema tenellum Spencer.
Figure 17 Specimen from Gasport lens. Figure 18 Same x 2 to show the

Two fragments of this delicate graptolite are contained in our collection of fossils from the Gasport lens of the Lockport limestone at Lockport, N. Y.

The species has been fully described by Spencer and Gurley (see Bassler, 1909). One of our specimens (here figured) is so preserved that the branches have partly weathered away and left in the rock the series of projecting thecae, now seen in circular sections. The

specimen shows thereby that the thecae of the feeding individuals were all projecting on one side only, as usual in Dictyonema, and numbered 22–26 in 10 mm.

Inocaulis plumulosus Hall

The genotype of the genus Inocaulis, I. plumulosus Hall, has been quite fully described by the writer in the Graptolites of New York (1908, p. 188.) The short tubular processes of the stems representing the thecae and the pores from which they arise, were there noted and figured.

We describe in another place in this bulletin and figure the complicate interior structure of the stems or stipes of I. lesquereuxi, consisting of bundles of ropelike twisted fibers. A similar composition of the branches of I. plumulosa of black (originally chitinous ?) fibers is also seen in a few specimens. The fibers are, however, not spirally twisted in the cases seen, as in the other species, but are parallel to the general direction of the branch.

Inocaulis lesquereuxi (Grote & Pitt)

Plate 12, figures 1 and 2

Inocaulis lesquereuxi was originally described as a seaweed. Its graptolite nature has been shown by the writer (1916, p. 13) and the form fully described. It is therefore not necessary to enter here again into a discussion of this interesting fossil.

We wish, however, to publish a figure of a beautifully preserved perfect colonial stock, a foot in width, which has come to hand through the collecting ardor of E. Reinhard, and which gives a fair idea of the bushlike habit of this thick-branched, stately graptolite.

In the former publication we described the marginal projecting thecal tubes and the punctae or pores of the surface of the branches. Excellent material has now been afforded from the Buffalo quarries, in which the stipes were macerated before burial in the mud to such an extent that the composition of the interior of the stipes of more or less spirally twisted bundles of fibers is shown. In some cases the whole mass of fibers has been separated into ropelike bundles of twisted fibers, as many as seven of which were counted at the same level, indicating a quite complicate interior structure of the stipes.

Still another detached branch is figured here, because it exhibits a club-shaped swelling of the terminal portion of a branch, the meaning of which is not known at present.

Inocaulis ramulosus Spencer

Inocaulis ramulosus Spencer, Trans. Acad. Sci. St Louis, IV, 1884, p. 565, 588, 589, pl. 6, fig. 1; Bul. Museum. Univ. State Missouri, 1, 1884, p. 15, 38, 39, pl. 6, fig. 1.

Inocaulis ramulosus Bassler, Smithson. Inst. Bul. 65, 1909, p 49–50, figs. 63, 64.

Figure 19 Inocaulis ramulosus Spencer. Fragment. Natural size.

The Gasport lens of the Lockport limestone at Gasport, N. Y., has afforded several specimens of this species that was hitherto known only from the Lockport limestone at Hamilton, Ontario. It has been fully described by Spencer and Gurley (Bassler, p. 50). We may add to this, that the branches of the specimen here figured, exhibit small oval apertures, not more than .2 mm wide in largest diameter. While most of the branches appear smooth, one of them (on left margin of specimen) exhibits a series of liplike processes of the apertures.

Inocaulis akronensis nov.

The Akron waterlime at Akron, N. Y., has afforded to Mr Reinhard two blocks which contain, on one surface, numerous fragments of an Inocaulis that is distinguished from the Bertie species I. lesquereuxi by its much smaller dimensions; the branches being, on the average only 1.5 mm wide, with 2 mm apparently as a maximum. It resembles in the size of the branches some of the congeners from the Lockport limestone, as I. ramulosus and diffusus Spencer. The material at hand is not sufficient to distinguish it from these earlier species, yet it is reasonably certain that it is not identical with any of the Lockport species, by reason of the long time interval and the fact that no other forms are common to the two widely separated formations.

None of the fragments is longer than 13 mm; the bifurcation seen in one fragment, takes place by a very small angle (less than 10°). The fragments suggest a certain rigidity or straightness of the branches.

The fingerlike projecting thecal tubes are finely seen on some of the branches. They are as figured by the writer from Inocaulis plumulosus Hall; but quite minute, about .9 mm to 1 mm long and .15 mm to .2 mm wide.

Leveillites hartnageli Foerste

Doctor A. F. Foerste (1923, p. 62) has elaborately described a Leveillites hartnageli a beautiful fossil from the Siluria[S] Manitoulin limestone at Credit Forks, Ontario.

It is shown by Doctor Foerste that the frondlike expansions bear a middle axis and consist of anastomosing black fibers. In addition to these, series of black dots are seen to occur, about 5 or 6 in a width of .5 mm, from which hairlike fibers extending beyond the margins of the lobes can be traced. Doctor Foerste argues rightly that the fibers have too much consistency to be comparable with the fibrous structures traversing the interior of algae and possessing a very small quantity of carbon. It is stated that the fibers resemble the fibers of sponges more than those of plants, but a reference to the sponges is rejected because there is no trace of oscula or other characteristic structures of sponges. It is added (p. 61): " Possibly they belong to some group of animals not yet discriminated from those recognized so far."

The name is given from the resemblance to the fronds of the living alga Leveillea jungermannoides (Mart. & Her.) Harvey.

When we first saw the fine specimen collected by Mr Hartnagel in 1913 our impression was that the fossil would finally prove to be a hydrozoan. The study of the graptolites of the genus Diplospirograptus here described leads the way to the understanding of Leveillites. There is no doubt in our mind that Leveillites is closely related to Diplospirograptus and that the apparent flat frondose lobes are really bundles of thecal tubes such as are seen to proceed from the double spiral axis in Diplospirograptus. The rows of black dots are either the apertures of the thecae or the attachment places of the hairlike fibers.

As Chapman has shown Mastigograptus and other similar forms to be hydrozoans, this genus may also finally be brought under the Hydrozoa and the writer's original vague impression turns out to have been correct.

Medusaegraptus gen. nov.

Μέδουδα Medusa + γράφειν to write

Diagnosis. Rhabdosome consisting of simple, not branching stipe, which is a uniformly thick tube, ending in a blunt point at the base and terminating distally in a dense mass of simple, unbranched flexuous thin tubes, the thecae.

Genotype. Medusaegraptus mirabilis *nov.*

Medusaegraptus while clearly belonging in the same group with Inocaulis, represents a separate development by lacking the frequent branching of the stipe, possessing a single stipe and terminating proximally into a tap rootlike basis, obviously for anchoring in the mud. The densely arranged filamentous appendages are marked by uniform width and abrupt extremities, indicating that they probably were tubular bodies and functioning as thecae for the zoöids. They are connected by pores with the interior of the thick stipes. The latter were filled with bundles of tubes, as in Inocaulis. In older colonial stocks the lower part of the stipe becomes smooth and much thickened, the filamentous thecae having been stripped off, probably after the death of the older zoöids of the colony. As the figures show, all stages between smooth stipes, such with short basal stubbles of the thecae and fully preserved long thecal tubes at the extremity of the colonial stock are seen. Plate 10, figure 4 represents the final old stage of the genotype; plate 8, figure 4 a similar condition in the smaller congener Medusaegraptus graminiformis (Pohlman). In M. graminiformis distinct evidence of a composition of the stipe of bundles of fibers as in Inocaulis has been seen.

The basal pores of the thecae are found only on the upper portion of the stipe, the lower being smooth and furnished with a thickened periderm. The pores are very closely arranged, in quincunx fashion, forming intersecting spiral lines.

The thecae, as seen in the genotype, are long tubes beginning narrow at the base but widening rapidly to a uniform width observed in all the appendages. Sections of the thecae in the rock leave no doubt that the tubes were hollow and thin walled, without any inner structures; the apertures round and straight transverse. We are, however, not at all sure that these long thecal tubes were not covered by still finer filaments or tubes. Suggestions of such a still finer set of appendages were noted in several places, at least in the genotype; as well as small pustules on weathered thecae, which may have been the attachment places of these further appendages.

Medusaegraptus graminiformis (Pohlman)

Plate 8, figures 1–4, pl. 13, figure 1

Chondrites graminiformis Pohlman. Bul. Buffalo. Soc. Nat. Sci., V. no. 1, 1886, p. 32.

Description. Rhabdosome consisting of long (4 or more cm). uniformly narrow (.6 to 1.2 mm wide) stipes, terminating at the base into a blunt point, distally into a small " head " with densely

crowded, extremely delicate, unbranched filaments, probably the thecae. These are barely .1 mm wide and about 10 mm long. The basal pores of the thecae number five in the width of a stipe.

Horizon and locality. Bertie waterlime and Akron dolomite, Buffalo, N. Y.

Remarks. Doctor Pohlman described this form as a " marine plant " as follows:

> Chondrites graminiformis sp. nov. Fronds brittle, with few dichotomous branches in acute angle of divergence, all exactly linear by compression, more or less flexuous, generally broken in short fragments; surface covered with thin, smooth, coaly pellicle.
>
> These fragments are numerous and very distinctly traced in black upon the grayish-white and colored slabs, 1 to $1\frac{1}{2}$ mm broad, mostly short, from $\frac{1}{2}$ to 3 cm long, the longest fragment preserved being a curved branch 5 cm long. They are spread upon the stone in every direction and in such a way that the primary divisions of the frond can not be recognized. For all the fragments are simple, or with only a branchlet diverging in a very acute angle near the top of a few of them.

Pohlman did not figure his new species, but we have before us his type specimens (Buffalo Museum, 13312–1641), through the kindness of the director of the Buffalo Museum, William L. Bryant. These show that there is no dichotomy observable, and the apparent bifurcations are due to overlapping of stipes. While none of the stipes exhibits the " head " of filamentous thecae, a number of stipes in the middle of the slab bearing the types, show very distinctly, under the lens, the crowded stubbly bases of the filaments, all directed upward; exactly as in all stripped specimens of Inocaulis and Medusaegraptus. The filaments were so delicate that but very few specimens were observed exhibiting the " head " and the stipes apparently so brittle, that although the Buffalo Museum contains slabs (as $\frac{13272}{\text{E}1601}$) a square foot or more in size and densely covered with these fossils, only fragmentary stipes are seen, lacking the base and top and mostly reduced to a smooth flattened tube.

The specimen, reproduced in plate 6, figure 4 is the best that came under our observation.

Besides these mostly fragmentary larger stipes, there occurs in the Bertie waterlime a smaller form which we had originally separated as M. sedum taraxaci. The characters of these striking minute fossils (see plate 6, figures 2 and 3) are as follows:

Stipe mostly averaging 5–10 mm in length. Width quite uniformly .6 mm. Thecal tubes forming a small "head", only .05 mm wide, rather rigid, bristlelike, 6–10 mm long. Base acuminate.

These minute fossils occur always by themselves in multitudes on the surface of slabs, separated from the mature M. graminiformis. Since both forms, from their shape and the fact that numerous young individuals are still found upright in the mud (see plate 6, figure 3), must have grown anchored in the mud by their tap roots, it is hard to see how such a separation of assemblages of different growth-stage could have come about. It is, however, quite probable that the larger assembled specimens represent mature settlements that were overwhelmed by an inflow of mud, while the smaller ones are new settlements that were formed after such a catastrophe and failed to reach full growth before a new catastrophe intervened. The fact that practically all mature specimens of M. graminiformis are only broken fragments, lends support to the view that storms that reached the bottom and tore off the stipes and shifted the mud, were the principal cause of the destruction of the graptolite meadows.

The complete rhabdosomes of this graptolite must have reached considerable length, for the fragments do not show any increase in width and the rate of growth was obviously very slow, requiring a length of possibly a foot and more for the stipe to attain its full width. It would also seem that the stipes were not by any means as flexuous as the curvature of the fragments would suggest and were therefore apt to break into the multitude of fragments we find now scattered over the slabs.

The stubble of broken-off thecae observable on mature fragments of M. graminiformis, indicates that the theciferous portion often had a greater length than the "heads" would indicate.

This species is one of the commonest forms of the Bertie; a few specimens have also been found in the Akron dolomite, at Akron, N. Y.

Medusaegraptus mirabilis nov.

Plate 9, figures 1–6; plate 10, figures 1–4, plate 11, figure 1

Description. Rhabdosome large, attaining a length of 10 cm or more. Stipe straight or but slightly curved, sometimes bent hooklike at the base. Width of the stipe 2–3 mm. Thecae flexuous, attaining a length of 6 mm and 1–1.5 mm wide in the distal portions, but only .2 mm wide near the base. Basal pores of thecae a little longer than wide, about .2 mm wide, and about the same distance apart. A short ridge leads up to the slightly elevated rim from

below. In old colonies the theciferous portion is reduced to a short "head," only about 10 mm long, while the stem is 10 times as long. The distal end of the stem is rounded.

Horizon and locality. Lockport limestone (Gasport lens), at Gasport, N. Y.

Remarks. This is by far the most striking of the graptolites of the Dendroidea, among the graptolites, found so far in the Silurian of New York, though far surpassed in size by associated species of Dictyonema.

The supposed thecae, long filiform tubes are bent in all specimens in such a way as to suggest a considerable degree of flexibility except in one where they are spread out as straight, radiating lines. This arrangement may, however, be also a result of the drifting of the filaments with the current.

Palaeodictyota buffaloensis nov.

This species is based on a single specimen from the Bertie waterlime at North Buffalo, N. Y. The rhabdosome, in the fossil condition, forms a subcircular patch about 75 mm in diameter. The meshes are irregularly polygonal to circular, for the most part, varying in diameter from 4 mm to 10 mm or more; the branches, on the average are about 1 mm wide.

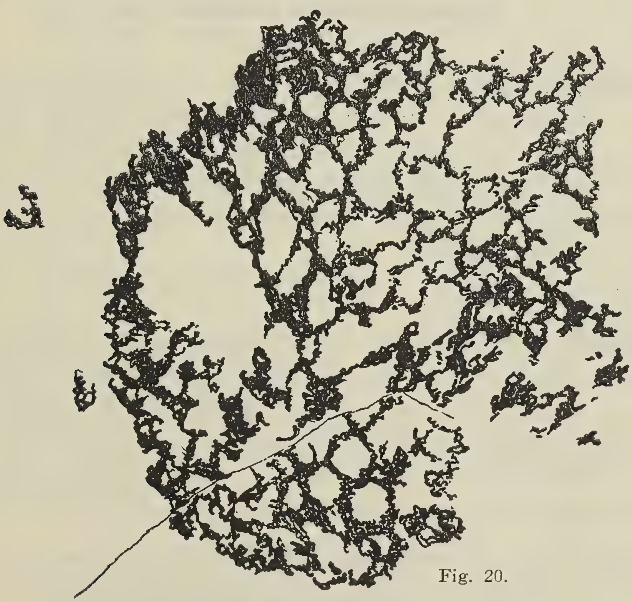

Fig. 20.

Figure 20 Palaeodictyota buffaloensis nov. Holotype. Natural size.

The thecal tubes and apertures have not been made out clearly enough to give their dimensions; indeed the specimen is so badly weathered that the only excuse for describing it is the interest that attaches to the occurrence of this genus of graptolites in the Bertie waterlime, the congeners only being known from the Clinton and Niagaran formations.

Diplospirograptus gen. nov.

(Διπλόος double, δπεῖρα coil, γρφειν to write)

Diagnosis. Rhabdosome consisting of tubular stipes which bear the theciferous branches. The first stipe bifurcates near the base, the resulting branches of the stipe are spirally coiled around each other; each branch doubly bifurcating again at long intervals.

Generic type. Diplospirograptus goldringae Rued.

Probably this genus represents an aberrant offshoot of the simpler genus Inocaulis with which it has the tubular stipes and more or less filamentous theciferous branchlets in common. Peculiar to this genus are the strange spiral coiling of the branches about each other, apparently for mutual support and the frequent bifurcations of the branchlets.[1]

Diplospirograptus goldringae nov.

Plate 7, figures 1–6

Description. Stipe doubly bifurcating 2 or 3 times, the resulting pairs of stipes each forming a close spiral. Whole rhabdosome 70+ mm long, the bifurcations about 20+ mm apart; the stipes about 1 mm wide; with theciferous branchlets 5–8 mm wide; the branchlets densely crowded, branching several times, about .2 mm wide, of uniform width.

Horizon and locality. Lockport limestone (Gasport lens), Gasport, N. Y.

Remarks. Although we have considerable material of this strange graptolite, it is mostly so completely flattened and the aspects of the stipes are so varying, that it proved a difficult matter to arrive at a final conclusion as to the structure of the form. Some slabs are covered with stipes that are stripped of the branchlets. Specimens as that reproduced in plate 7, figure 1, connect the cat-

[1] The spiral axes, are, according to Professor O. Abel, who saw this graptolite, comparable to the spirally twisted stems of water plants, such as Potamogeton lucens or of certain species of Platycrinus and to be considered as a reaction of the colony to strong currents.

taillike complete branches (see plate 7, figure 4) with the stripped stipes. The latter mostly appear like a series of beads and it is mainly through specimens as that shown in plate 7, figure 2, where the two associated stipes have separated, that the spiral winding of the stipes is recognized. Numerous fragments (see text figure 21) show the spiral arrangement directly, when studied under water. A few, especially well-preserved fragments exhibit numerous pores, surrounded by raised rings, which we take to be the bases of the filamentous branchlets. The latter bifurcate several times; the segments are rather stiff in appearance, often slightly widening distally; the bifurcations are of such an appearance as to suggest budding of new thecae; the final terminations are abrupt and not threadlike tapering; the whole thus suggesting that the branchlets are composed of thecae, the segments between the bifurcations each representing one theca. The fundamental structure would then be similar to that of Inocaulis. No evidence, however, has been seen of a composition of the stipes of numerous fine parallel tubes, as in Inocaulis. It is, however, interesting to note that the bundles of fine tubes in Inocaulis are also spirally coiled within the stipes, and it is therefore possible that Diplospirograptus represents a branch of Inocaulis in which the inclosed bundles of tubes have become separated exteriorly, instead of remaining united under a common periderm.

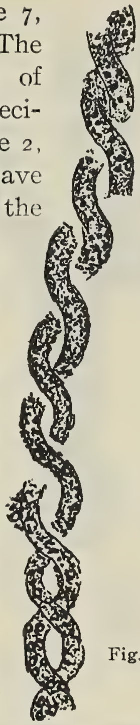

Fig. 21.

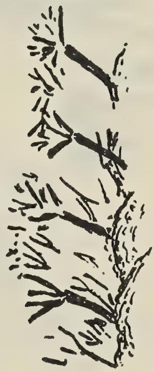

Fig. 22.

Figure 21 and 22 **Diplospirograptus goldringae** nov. Figure 21 Enlargement (x6) of double spiral axes. Figure 22 Enlargement (x6) of theciferous branchlets. Figures 21 and 22 are camera drawings.

The branchlets are arranged in double spiral series, as shown by the specimen reproduced in text figure 21: one series each on the outside of each of the stipes.

Thallograptus gen. nov.

(θαλλός a young branch, γράφειν to write)

The dendroid genera Dendrograptus and Inocaulis have been made the receptacles for a number of species which differ fundamentally

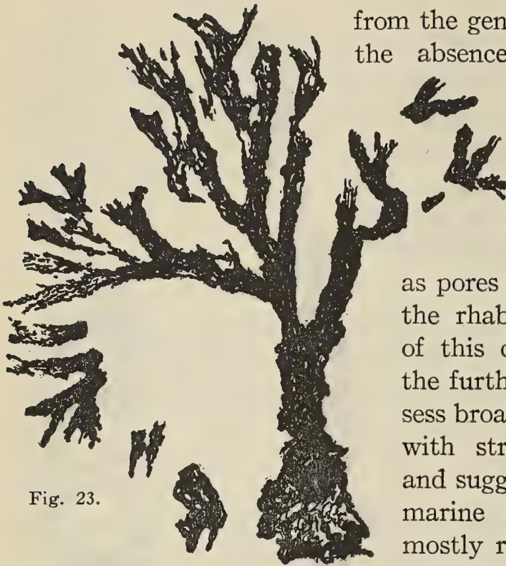

Fig. 23.

Figure 23 Thallograptus phycoides (Spencer).
Specimen from Rochester shale at Lockport, N. Y. Natural size.

from the genotypes of these genera in the absence of exterior projecting thecae, either in the forms of slender tubes or of shorter cuplike receptacles. In the species here to be segregated the thecal apertures appear as pores on the general surface of the rhabdosome. In recognition of this differential character and the further fact that they all possess broad or rather thick branches with strong carbonaceous films and suggest in their general habit marine algae, they have been mostly referred to the respective graptolite genera with doubt. The composition of the branches of chitinous tortuous tubes and the regularly arranged thecal apertures warrant, however, their placing with the graptolites.

We propose to unite these graptolites of vegetable habit and lacking the projecting thecae under the generic term, Thallograptus. Among others there will belong here:

Dendrograptus (?) succulentus *Rued.* (genotype).
D. dubius *Miller* (D. simplex *Spencer*).
D. frondosus *Spencer*
Inocaulis cervicornis *Spencer.*
I. phycoides *Spencer.*
I. (?) strictus *Spencer.*
I. vegetabilis *Gurley.*
I. ? thallosus *Gurley.*

It is the writer's intention to revise the genera of the Dendroidea in a forthcoming monograph of the graptolites of North America. At that occasion this genus will be more fully discussed.

Thallograptus phycoides (*Spencer*)

Inocaulis phycoides *Spencer.* Canadian Nat. X, 1882, p. 165 (nomen nudum); Trans. Acad. Sci. St Louis, IV, 1884, p. 565, 588, pl. 5, figs. 6, 7; Bul. Mus. Univ. State Missouri, I, 1884, p. 15, 38, pl. 5, figs. 6,7; Gurley, Jour. Geol. VI, 1896, p. 99, 309; Bassler, Bul. 65, U. S. Nat. Mus. 1909, p. 51–52, fig. 66; Bassler, U. S. Nat. Mus. 92, 1915, p. 666.

We have before us an excellently preserved specimen of this species from the Rochester shale at Lockport, N. Y. The species

was hitherto known only from the Lockport limestone at Hamilton, Ontario.

The specimen exhibits in one part the interior fibrous structure. There are no marginal thecal projections and the apertures appear as minute pores on the finely lineated or smooth surface.

On account of the absence of the exterior projecting thecal tubes, seen in the genotype of Inocaulis, namely, I. plumulosus, this form can not be brought under the same generic group. The thecae appear here to have extended only as far as the general surface, where they had simple pores for apertures.

Climacograptus ultimus nov.

Plate 12, figures 3 and 4

Fig. 24.

Fig. 25.

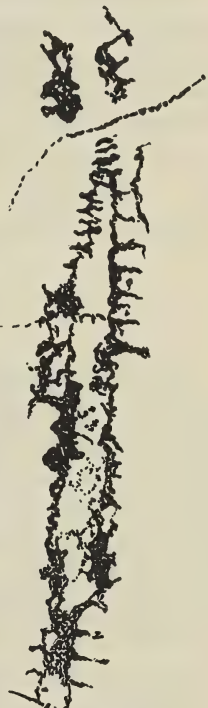

Fig. 26.

Figures 24 and 25 Climacograptus ultimus nov. Two stipes (types) x3.

Figure 26 Orthograptus (?) sp. Apparent stipe of Orthograptus from the Bertie waterlime at Buffalo, N. Y. x3.

Description. Rhabdosome minute; most specimens 3 mm long, a single one 5 mm long was observed; .5 mm wide, of uniform width. Thecae numbering about 23 in 10 mm (7 in a length of 3 mm). Apertures small, straight or slightly introverted. Outer margin straight or somewhat concave. Septum but little undulating, almost straight. Sicula and virgula unknown; virgella short.

Horizon and locality. Bertie waterlime at Buffalo, N. Y.

Remarks. We have but a single slab of Bertie waterlime with this fossil. This, however, is densely covered with the very minute graptolite stipes, in association with a large leg-spine of Eusarcus.

The principal interest of this insignificant fossil lies in the fact that it is found long after the graptolite genus Climacograptus has disappeared in our formations and supposedly was extinct. It is the first Climacograptus found in the Silurian of America. In Europe the genus is known to persist into the Silurian and the last of the British Climacograpti, namely, C. extremus H. Lapworth, from the Tarannon shales (base of Rhayader Pale Shales) is so similar to our form, that the two may prove vicarious species.

The main difference seems to lie in the still smaller dimensions of our form and the less undulating septum, but our material is not so favorably preserved as to give certainty about this last character. The New York species occurring in the Bertie waterlime is still considerably younger than the British Tarannon form and therefore probably the last Climacograptus that has so far come under observation. It is an interesting instance of the long post-climacteric persistence of a genus in much reduced state, both as to number of species and size of individuals.

Orthograptus (?) sp.

Plate 12, figure 5

A single specimen of a large graptolite from the Bertie waterlime suggests the occurrence of a late species of Orthograptus or Glossograptus in the Middle Silurian. Unfortunately the fossil is too poorly preserved, being partly abraded, for positive determination. There is hardly any other feature observable, but the large square thecal apertures and sections besides patches of a firm continuous test. There is no trace of the reticulate structure as is seen in the Silurian Retiolitidae.

III ANTHOZOA

Ceratopora (?) sp.

Plate 15, figure 5

Some bedding planes of the Bertie waterlime at Buffalo contain remains of an organism, that, as is the case of so many fossils in the Bertie waterlime, have been nearly destroyed by the diagenetic processes accompanying and following sedimentation. A few specimens that luckily escaped destruction, as the one figured, show a distinct outline consisting of more or less bent, conical tubes that multiply by lateral budding. The form of the tubes and the mode of budding strongly suggest the coral genus Ceratopora Grabau (1899, p. 132). The specimen figured is partly preserved in section and this exhibits fairly strong calcareous walls and, in one place at least, a distinctly thickening of the walls by the formation of cysts which bear short, thick spines.

While the material is not sufficient to diagnose clearly the genus or describe the species, it serves to indicate the occurrence in the Bertie waterlime, of tabulate corals related to Ceratopora and it also serves to suggest the amount of destruction of fossils that has gone on in the Bertie waterlime.

IV HYDROZOA

Stromatopora sp.

Some irregular nodular projections in the Bertie waterlime, covered by a delicate carbonaceous film, could be recognized as the last remains of stromatoporas by the presence of astrorhizae, concentric lines along the margins and pores. The calcareous bodies (hydrophytons) have entirely disappeared and only the traces of carbonaceous matter have been left behind, preserving clearly, at least in patches, the original surface of the organism and near the margins concentric lines resulting from lateral views of the laminae, that were dissolved.

The fossils remind of S. galtensis (Dawson), as figured by Clarke and Ruedemann (1903, pl. 1, fig. 13) from the Guelph of New York. They are mainly interesting as attesting the presence of these hydrozoans in the Bertie sea and as showing the extent to which complete destruction by dissolution of calcareous shells and structures has been carried in the deposition and metamorphism of the Bertie waterlime.

V CYSTOIDEA

Pyrgocystis batheri nov.

Plate 13, figures 2–5

Description. Turret subcylindrical, about as high as wide; measuring about 5 mm in either direction. Turret-plates in eight columns of twelve plates. Each plate is shallowly concave, a little longer (about $\frac{1}{4}$) than wide and of broadly subelliptic to nearly circular shape with a straight or concave truncation at the base. The largest plates are 2–5 mm long; most measure about 2 mm or less. The amount exposed about one-fourth. The distal (basal) plates are nearly horizontal, smaller than the others, nearly circular in outline and not distinctly arranged in tiers. The plates are thick (.3 mm), smooth or of very finely granular surface; no spines have been observed. Oral face missing, the immediately surrounding plates smaller than the rest.

Measurements. The specimen, plate 13, figures 2–5, which is the only free one observed and is selected as the type, is apparently compressed vertically. It is 3.9 mm high on the longer convex side, 3.2 mm long on the opposite side; its greatest horizontal diameter is 6.5 mm; at a right angle to this it measures 4.5 mm in width.

Horizon and locality. Bertie waterlime, Bennett's quarries, North Buffalo, N. Y.

Remarks. The genus Pyrgocystis has been erected by Bather (1915, p. 49 ff) for an extremely interesting group of fossils that were

first brought to light in the Silurian of Gotland and described by Aurivillius as cirripedes, being referred to the recent genus Scalpellum. Bather, noticing upon the edges of the plates in British material, the clean crystalline cleavage distinctive of calcite and of echinoderm stereom, recognized their echinoderm nature. In one British species, P. grayae, the oral face was found and this furnished the final proof of the cystid nature of this group of forms.

The relationships of Pyrgocystis have been fully discussed by Bather, who refers the genus for the present to the Edrioasteridae, in his excellent studies in Edrioasteroidea. Six species are described by Bather, one of these, P. sardesoni from the Lower Ordovician Decorah shale of Minnesota; another, P. grayae from the Upper Ordovician of the Girvan district in Scotland; one, P. ansticei from the Middle Silurian (Wenlock shale) of Shropshire, England: and three of Aurivillius' species (reduced from seven species originally distinguished by Aurivillius) from the Wenlock shale of Gotland. To this is added with our Bertie waterlime form, a seventh type from the Middle Silurian of New York.

We have altogether three specimens before us one, the type, entirely free, but apparently obliquely compressed; the two others close together on a small fragment of rock. These, while compressed laterally indicate the original straight cylindrical form of the turret.

VI VERMES

Protoscolex batheri nov.

Plate 14, figures 1 and 2

Diagnosis. Segments bear each two rows of papillae, of which thirty or more are visible on one side of the compressed fossil. Spaces between papillae equal or are less than the diameter of a papilla. Height of a segment about .7 mm. Width of a specimen about 4.3 mm. Ratio of segment height to width 16/100.

Horizon and locality. Lockport limestone (Gasport lens) at Gasport, N. Y.

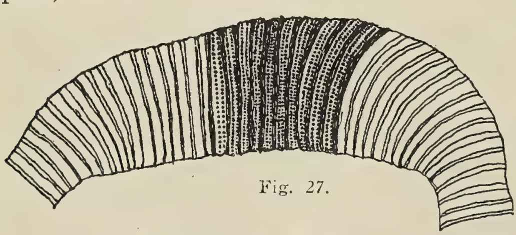

Fig. 27.

Fig. 28.

Fig. 29.

Figures 27–29 Protoscolex batheri nov.

Figure 27 Middle portion, showing clitellum and double rows of papillae on segments. x3.

Figure 28 Anterior end; fig. 29. Posterior end. x3.

Measurements. The holotype (plate 14 figure 1) measures about 118 mm in length: is 4.3 mm wide; and consists of 147+ (about 168) segments.

Remarks. The genus Protoscolex was erected by Ulrich (1878, p. 89) for four species of worms from the Eden series (Economy formation) near Covington, Ky. Later, Miller and Faber (1892, p. 83) added a fifth species from a lower horizon (the Fulton shale), and recently Bather (1920, p. 124) has elaborately described a congeneric form from the Lower Ludlow of Herefordshire, England, as P. latus. We have now before us a further species from the Silurian Lockport limestone near Gasport, N. Y. There are altogether three specimens, two fragmentary, and one complete with counterpart. The latter, the type of our species, is so well preserved that not only both extremities are clearly seen and the segmentation shown, but also the rows of papillae distinctly exhibited as whitish spots in several portions of the fossil. The segments are in some parts separated by deep furrows, of equal width with the papillae-bearing ridges, apparently the result of shrinking, for in other parts they appear only separated by sharp transversal lines. A shallower depressed transversal line passes between the two rows of papillae. The latter are for the most part of equal size, and the single papillae of the two rows as a rule are opposite each other, although in some parts they appear to be alternating. One end is sharply rounded. This retains the anus and is by the latter and the position of the supposed clitellum (see postea) marked as the posterior end. The other end is sharply drawn out, acutely pointed and that portion of the worm altogether narrower than the rest, the fossil thereby looking exactly like an earthworm that is moving.

Our species differs from its congeners by its greater absolute size and also relatively coarser structure, the segments being relatively higher; the ratio of segment height to width being twice that observed in P. latus Bather; while on the other hand, the papillae appear to be smaller and more closely arranged, there being eighty or more visible in our specimen in a width of 4–5 mm, against twenty in a width of 3 mm in the British specimen.

While P. latus exhibits as its most noteworthy feature a thickening of the median line regarded as the gut of a mud-eating worm by Bather, our most complete individual has a special interest of its own by retaining a swelling, suggesting the clitellum. This is shown in the greater width (6 mm, as against the 4.3 mm of the rest of the worm), attained abruptly in the space of two or three segments. Still more than by the width is the swollen part set

off by the deep wide intersegmental furrows and the light gray color of the test, which in the remainder of the worm is dark brown, except the part directly in front of the clitellum which is also gray. The deep intersegmental furrows serve to give the aspect of an originally swollen condition and a later stronger shrinking to that part. The swollen part, which we consider as corresponding to the clitellum of the recent oligochaetes, is about 25 mm long and spreads over about thirty-eight segments.[1] There are more than forty-five segments in the shorter remainder of the worm, which we consider, on account of the location of the clitellum forward of the middle of the recent worm as the anterior portion.

The presence of a clitellum is also important for the taxonomic relations of Protoscolex. In discussing the probable systematic position of Protoscolex, Bather says:

It is to the Oligochaeta that Protoscolex presents the strongest resemblance. The general shape, the close and undifferentiated annulation, and the long simple gut are all suggestive of that order. The apparent absence of a clitellum is by no means fatal, for that structure is very slightly developed in the primitive Moniligaster, and in most aquatic Oligochaeta appears only periodically. Therefore in Protoscolex it may not have reached such a stage of evolution to be discernible in the fossils, or the animals may have perished out of the breeding-season.

The holotype of P. batheri happily supplies this missing character and completes the chain of evidence supporting the reference of Protoscolex to the Oligochaeta.

If Protoscolex is an obligochaete, then there is no reason, as Bather shows, why it should not be referred to the Perichaetidae and the papillae should have carried setae. In that case we see in the fossil before us an ancestral representative of our earthworms which it so strikingly resembles. This might lead some of those who are strenuously seeking for evidence of land life in our Silurian rocks to consider these early Perichaetidae as land animals washed into the marine Lockport beds, but as Bather correctly says:

It may be objected that the Oligochaeta, especially the group to which the Perichaetidae belong, are normally terrestrial, or, at most, inhabitants of fresh water. There is, however, *a priori* reason to suppose that terrestrial oligochaetes were derived from aquatic, and ultimately marine, forms.

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[1] It is true that the recent Oligochaeta have a smaller clitellum, comprising not more than eight segments, but it is to be considered that the swollen segments correspond to the size of the coccoon which they secrete and their number therefore was probably subjected in earlier times to considerable variation, with a tendency to a greater number in marine forms where larger broods are produced under the influence of a multitude of enemies.

And if those friends of mine who relegate the eurypterids into the rivers and their associates onto the land, persist too stubbornly, I shall meet them on common ground by urging that these Silurian angleworms obviously dropped from fishhooks where they had been carelessly fixed.

I am taking great pleasure in naming this important and interesting fossil species after Dr F. A. Bather, who has advanced our knowledge in nearly every branch of paleontology.

Bertiella obesa nov.

Plate 14, figures 3 and 4

The Bertie waterlime at Buffalo, N. Y., has afforded two specimens of a very plump " worm " that we have failed to connect with one of the few annelid genera so far described and that at the same time is so lacking in diagnostic characters that we can not place it with certainty in any of the classes of the Annulata and will describe it under the trivial and neutral term Bertiella obesa.

The larger specimen, which we select as the type, is about 118 mm long, measured on the outside of the curve; and 13 to 15 mm wide except the supposed foremost portion (10 mm long) which is 8 mm wide. The animal was therefore in a probably much contracted position, less than 10 times as long as wide. The anterior extremity is sharply rounded, the posterior one not fully preserved. The annulation, which has to be studied under water, is distinct in some parts, but owing to the violent bending of the fossil, quite irregular and indistinct in others and the number of segments can not be definitely determined. The segments appear flat or slightly convex in the middle, the constrictions are shallow. The segments were on the average about 1 mm wide (they are 1.5 mm wide on the outside of the curve and less than 1 mm on the inside), and numbered therefore more than a hundred. The surface of the segments is for the most part smooth, but in some parts are seen distinct circular nodes, a little narrower than the segments, to which in other parts of the fossil circular carbonaceous patches seem to correspond. There is in several places, especially near the front, an indication of a longitudinal serial arrangement of these nodes, about two series on the visible side.

At one extremity two converging, slender, subtriangular carbonaceous bodies are distinctly seen, that strongly suggest jaws. They are 2.5 mm long.

The smaller individual (cotype) is 45 mm long, 10–12 mm wide; abruptly rounded at both ends. One half shows very distinct seg-

mentation, the segments being quite uniformly 1.5 mm wide; the other half appears smooth with but faint traces of segmentation. There are indications of papillae, but none of jaws.

From the manner in which the worm contracted himself, one can not help being reminded of the leeches. The absence of suckers and the form of the jaws, however, do not corroborate that suggestion. The size of the parapodia and the form of the jaws indicate a taxonomic position with the Chaetopoda; the absence of distinct setae makes also this relationship doubtful.

Dactylethra gen. nov.

(Δακτυλήθρα, a finger-sheath)

Dactylethra conspicua nov.

Plate 15, figure 12

We propose to describe under the name given in the heading a problematical fossil from the Gasport lens of the Lockport limestone.

The fossil consists of black bodies of the shape of the fingers of a glove; rounded and closed at one end, hollow and more or less filled with sand in the middle and open at the other end. The closed end is in two specimens rather sharply bent sideways. The test appears to have had a leathery consistency, it is distinctly wrinkled in several specimens and slightly offset in another, while smooth and suggesting a firm tube in others. The open end shows a torn or irregular edge. The specimens range in length to about 10 cm as in the case of one kindly sent to us for inspection by Dr F. A. Bather, keeper of the British Museum. Our best specimen is 80 mm long, 19 mm wide and 3 mm thick in the middle. Smaller ones are 13 mm wide. The black carbonaceous film covering the fossil is smooth, without any traces of sculpture.

As these peculiar fossils are associated with the large graptolites of the Gasport lens notably Medusaegraptus mirabilis, which possesses similarly shaped though much smaller tap roots, the first impression was that these bodies might be the bases of very large dendroid graptolites. No graptolite stocks have been found, however, that would at all approach a size necessary for these large basal tubes.

Worm tubes and burrows of worms or other animals suggest themselves, but nearly all the specimens of Dactylethra we have seen lie on bedding planes, and all appear to have had a horizontal position. The wrinkled, carbonaceous, at one end sharply bent and compressed fossil indicates that the organism had a fairly firm test that

was able to keep the tube open long enough to allow it to fill partially with sand.

The absence of marginal welts would not permit the fossil being placed with Serpulites.[1]

EXCREMENTA

Plate 14, figure 5

The bedding planes of some strata of the Bertie waterlime are densely covered with, or in some cases entirely composed of worm-like bodies. These have a uniform individual width, varying between 1 mm and 1.5 mm in the different specimens, and range in length, as a rule, from 10 mm to 20 mm. The extremities are rounded in complete specimens, in many, however, they are cut straight transversally.

While the fossils at first glance suggest a mass of worms, they fail to show any trace of segmentation or annulation, papillae etc. and are found on closer examination to be composed of flattened cylinders of sediment with enough organic matter to color them darker than the matrix. The only trace of sculpturing consists of faint longitudinal lines. Cross sections show sometimes a concentric structure.

There can be hardly any doubt that these bodies are either worm tubes or the excrementa of mud-eating animals, probably worms. Bertiella obesa here described would suggest itself, but it is not found associated with the excrementa and by the probable possession of jaws is shown to be a rapacious animal.

The fossils are of importance only in attesting to the abundant life in the Bertie sea.

VII BRYOZOA

Stigmatella sp

Like the stromatoporas and other calcareous structures, the bryozoans have left in the Bertie waterlime nothing but tenuous carbonaceous films. In one case such a film, about a square inch in size, finely retains the pores and acanthopores of a flat bryozoan zoarium, and these indicate a form belonging to or related to Stigmatella Ulrich and Bassler, a genus that is known from the Richmond and Clinton and may well have extended into the Bertie.

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[1] Professor O. Abel when shown our material, declared the fossils to be the ends of worm tubes. Similar forms occur in the Eocene and Cretaceous Flysch of the Wiener Wald in Austria and were exhibited at the 1923 meeting of the Paläontologische Gesellschaft, where R. Richter explained them as the posterior ends of worm tubes that extended horizontally or slantingly in the mud while the exit was by a vertical shaft. In the Eocene they possess a sericitic, glossy surface, resulting from a slimy effusion of the worms. To this latter may be also ascribed the dark film of our specimens.

VIII BRACHIOPODA

Orbiculoidea bertiensis nov.

The Bertie waterlime of New York has afforded four valves of Orbiculoideas, three from the outcrops about Buffalo and one from Sweet's quarry at Marcellus ("five feet above gypsum," D. D. Luther coll. 1899, Mus. loc. 2063).

All appear to belong to the same species, are of small size (the largest specimen measures 10 mm in diameter, the others about 6 mm), somewhat broader than long and flat. The pedicle slit extends from the subcentral apex to the margin and is rather wide. The brachial valve has the same outline as the pedicle valve, but may have been a little higher. Its apex is nearer by one-fourth of the centro-anterior distance to the anterior margin. The surface is marked by numerous strong concentric growth lines.

Fig. 30.

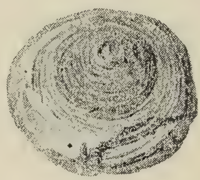

Fig. 31.

Figures 30 and 31 Orbiculoidea bertiensis nov.
Figure 30 Pedicle valve, x3. (Syntype).
Figure 31 Brachial valve, x3 (Syntype).
The original of figure 30 is from the Bertie waterlime at Buffalo; that of figure 31 from that of Sweets' quarry at Marcellus.

This species is very similar to the earlier O. molinensis Ruedemann of the Pittsford waterlime at Farmer's Mills (Ruedemann, 1916, p. 71), as may be expected with these indifferent forms. Its only difference, besides that of horizon, is the relatively greater width of the shell. Hall's O. vanuxemi (Hall 1859, p. 162) also recorded from the "waterlime group" is considerably larger and from the Manlius limestone.

Lingula lamellata Hall

Plate 15, figure 1

The Lockport limestone at Gasport has afforded half a dozen specimens of a medium-sized Lingula which in average size and outline are not sufficiently different from L. lamellata Hall (Hall, 1852, p. 249) to be separated from it, although the latter

is thus far recorded only from the Rochester shale. The average width is 11 mm, the length varies from 13–16 mm; its dimensions agree thus very fully with those of L. lamellata; likewise the anterior and posterior outlines, while the sides are a little more convex and not subparallel as figured by Hall.

Several of the specimens before us retain distinct color markings. One of these, here reproduced, is so well preserved that the prismatic layer retains a nacreous lustre where the surface layer has peeled off near the beak. The color markings consist of broad, sharp concentric bands, running in strict parallelism with the growth lines. Their color is brownish-black, those near the anterior margin being black, while towards the beak they fade to a light brown, the intercalated bands showing the drab color of the rock.

In L. media the bands are likewise concentric and dark brown in color, while the intercalated space is light yellow to white; the bands are here relatively narrower and sharper than in the larger species.

Color markings on fossil brachiopod shells have long been known. R. Richter (1919, p. 84) cites nineteen species, adding another one in Newberria (?) granulosa Wedekind. To these twenty species are to be added the American forms described by Greger (six species, 1908, p. 313; 1914, p. 93) and Cleland (three species, 1911, plates 12 and 13). These are of especial interest to us, because among them we find linguloids. Cleland describes and figures color markings of Lingula milwaukensis Cleland (plate 12, figures 3 and 4), and Lingula sp. (plate 12, figure 5), both from the Wisconsin Devonian, as possessing dark concentric bands. To this Greger (1914, p. 94) adds another Lingula sp. from the Grassy Creek shale (Devonian) of Pike county, Missouri, that exhibits dark blue concentric bands, which were at first attributed to variation in the thickness of the shell, but were, after the shell had been carefully removed from the matrix, recognized to be true color bands. An Orbiculoidea humilis Hall, from the Hamilton shales of the Canandaigua lake region (Greger, *op. cit.* p. 94) also retains " alternating concentric bands of light greenish horn and dark chestnut brown "; and the Newberria (?) granulosa described by Richter possesses concentric dark bands. The remainder of the brachiopods exhibit either uniformly colored (Crania modesta, W. & St. J., Discinisca lugubris Conrad, see Greger) or irregularly spotted or, the most common case, radially striated or spotted surfaces.

Lingula subtrigona Ruedemann

L. subtrigona is a peculiar form of markedly great anterior width, which gives it a distinct subtriangular outline. It was described (Ruedemann, 1916, p. 69) as coming from the " Manlius limestone " on Frontenac island near Union Springs, N. Y. It is, however, now known that there is no Manlius limestone on Frontenac island and that the bed so formerly considered is of Bertie age. (" The waterlimes below horizon of blue limestone," D. D. Luther; the blue limestone being now correlated with the Cobleskill by C. A. Hartnagel).

Lingula testatrix Ruedemann

This species has been described (Ruedemann, 1916, p. 67) from the Bertie waterlime at Litchfield, N. Y., which is in Herkimer county, in the eastern part of the Bertie waterlime belt. It is distinguished from the other Salina species by its relatively large size and broad form; except L. subtrigona, which has a markedly different outline.

It occurs also, reaching the same size, abundantly in the Bertie waterlime at Cayuga Junction and Hills Branch, Cayuga county (loc. no. 2057, J. M. Clarke & D. D. Luther, coll. 1899); and east of the road from Union Springs to Cross Roads station (loc. no. 2359, D. D. Luther, coll. 1899).

Some of the specimens from Cayuga Junction retain beautifully the concentric color markings, as does also a specimen from the drift at Canandaigua (loc. no. 2950.)

Lingula media nov.

While the Bertie waterlime at Litchfield, Herkimer county, N. Y., in eastern New York, has afforded the relatively large and broad L. testatrix and the waterlime at Union Springs, Cayuga county, in the center of the State, the peculiar subtriangular L. subtrigona, the Bertie waterlime at Buffalo contains a small form that in relative dimensions and outline holds the exact middle between the earlier L. semina Ruedemann from the Pittsford shale and the Bertie form L. testatrix. This new type which may be distinguished as L. media is on the average 4 mm wide and 7 mm long. It is hence still smaller than L. semina and relatively wider, while on the other hand, it is relatively longer than the larger L. testatrix. The brachial valves are well rounded at both extremities as in L. testatrix, while the pedicle valves are less contracted at the posterior extremity. There is, however, a distinct variability in this form, which is so

common on one bedding plane of the Bertie waterlime, that we counted on a slab of 9 square inches more than 200 specimens.

The phosphatic shells of this brachiopod are, in contrast to the mollusk shells, so well preserved as a rule in the Bertie waterlime, that the fine, relatively strong surface sculpture, consisting of concentric growth lines and also the color markings are preserved. The latter are more fully discussed under L. lamellata.

It is, however, an important observation for the understanding of the fauna of the Bertie waterlime, that while some blocks of Bertie waterlime are densely covered with the well-preserved shells of this pretty little Lingula, there have other blocks been found, where only vast numbers of delicate, elliptic carbonaceous shadows are seen with a black spot at one end. The aspect of these carbonaceous markings is so peculiar owing to the fairly sharp outline of the black spots that the writer was greatly mystified by them for some time until he could trace them through gradations into young Lingulas. In this case the phosphatic lime has been dissolved and only the organic matter been left, which is thicker at the beaks.

The carbonaceous films that remain of the younger Lingulas retain the subcircular black spot which occupies the place of the beak and may either mark the Paterina or Obolella stage of the shell, where the conch is still prevailingly corneous, or represent the base of the pedicle. Another interesting feature of these carbonaceous films is that many exhibit a distinct system of fine, crowded, wavy transversal lines. In one specimen of L. media, the corneous layer is preserved in a part of the shell, exhibiting the same system of delicate transverse lines. It is therefore probable that the transverse lines represent the structure of the corneous (chitin) layers of the shell in distinction to the concentric and radiating structure of the calcareous layers usually seen on the valves.

Similar transversal lines have been known for many years from the Clinton species L. lamellata Hall (=L. taeniola Hall & Clarke, see Hall 1852, pl. 20, fig. 4*a* and Hall and Clarke, 1892, pl. IV, fig. 8) and more recently been well figured of various Cambrian Atremata by Walcott (1912).[1]

Trematis spinosa nov.

Plate 15, figure 2

Description. Shell subelliptic in outline, 8 mm wide and 7.5 mm long; posterior margin wide, truncate, approaching a straight line. Brachial valve fairly convex, about one-quarter as high as long,

[1] See f. i. Obolella (Westonia) blackwelderi *op. cit.* pl. 39 figure 10.

sloping evenly from back forward. Beak small, elevated and projecting beyond the margin. Surface furnished with even, sharp, concentric lines, numbering 10–11 to 1 mm; surface rising towards the margin, into several higher rugae. Between the lines are fine punctae separated by more or less straight lines, transverse to the concentric lines. There are about twelve of these punctae to 1 mm. Toward the margin the porose surface is seen to be covered by a darker epithecal layer which extends into mucros and along the margins into spines, about 1 mm long.

Fig. 32.
Figure 32 Trematis spinosa nov. Pedicle valve x3. (Paratype).

~~Pedicle valve not known~~.

Horizon and locality. Lockport limestone at Gasport, N. Y., in association with Inocaulis plumulosus and other dendroid graptolites.

Remarks. The genus Trematis ranges in North America from the Trenton into the Richmond and may therefore be expected to go still higher in the Silurian, as it apparently does in Great Britain.

The Lockport species is readily distinguished from the congeners by the elliptic outline, the nearly straight posterior margin, the character of the punctae and the marginal spines. Not having seen the pedicle valve, our reference of the form, of which we have two specimens before us, to the genus Trematis, is mainly based on the characteristic surface sculpture. It would seem that the porous layer was originally entirely covered by the spinose conchiolinous epithecal layer.

Camarotoechia cf. **andrewsi** Prouty

A slab of Bertie waterlime at North Buffalo was found to be covered with fragmentary impressions of a middle-sized Camarotoechia. While the material is not favorably preserved for a conclusive determination, it is apparent that the species in outline, character and number of plications on the valve and in the sinus, best agrees with Camarotoechia andrewsi, a form described from the McKenzie formation of Maryland by Prouty (1923, p. 439).

Spirifer (Delthyris) eriensis Grabau

Plate 15, figures 3 and 4

Spirifer eriensis was described by Grabau (1900, p. 366) from the Cobleskill ("Bullhead") limestone of North Buffalo. It has since been recognized also in the Rondout limestone of the

neighborhood of Buffalo and in the Helderbergian (Keyser) of Maryland, New Jersey and New York (see Bassler, 1915, p. 1174).

The form is thus well established above the Bertie waterlime. Two specimens which Mr Reinhard has collected in characteristic Bertie waterlime of North Buffalo indicate that this species already existed before Cobleskill time. One of the specimens is very small (5 mm), the other, however, has the size of an average S. eriensis.

IX LAMELLIBRANCHIATA

Ctenodonta salinensis Ruedemann

Under this heading the writer (1916, p. 75) has described the only fossil so far known from the Salina beds. The type specimens came from the Camillus shale at Bull's quarry, town of Lenox, Madison county. A slab from the same locality is figured here (plate 3, figure 1) that was later found in the State Museum and which contains the little shells on the same surface with large "hopper-crystals", and with small worm tubes and trails. It would seem impossible that these lamellibranchs could have existed in the same water in which the large skeletons of salt crystals formed, and it must be assumed that on the mud flats of the Salina sea great local variations in the saltness of the water were found and rapid changes took place with varying influx of new water and evaporation.

Professor Harold L. Alling of Rochester has recently sent on representatives of this species which he collected at the gypsum locality at Garbutt, Monroe county, N. Y. They are also from the Camillus shale and occur on slabs with small worm tubes, trails and other evidence of a precarious organic life in that part of the Salina sea.

Rhytimya buffaloensis nov.

Plate 15, figures 6 and 7

Description. Shell small, compressed-convex, elongate, the length twice the height. Beaks small, little prominent, about one-third the length behind the anterior extremity; umbonal ridges and mesial sulcus very inconspicuous. Cardinal margin about five-eighths of length of shell, straight posterior to the beaks, declining fairly strong anterior to them; anterior end wide, sharply rounded above, uniformly curved in the middle and below; ventral margin, little convex, almost straight; posterior margin oblique, strongly rounded in the lower half; postcardinal extremity obtusely angular. Surface with irregularly alternating stronger and weaker concentric folds; in front of the beaks all folds thick and prominent. No radiating striae observed on the posterior slope.

Dimensions. The type specimen is 12 mm long and 6 mm high; the cotype is 7.5 mm long and 4.5 mm high.

Horizon and locality. Bertie waterlime, North Buffalo, N. Y.

Remarks. We have only two specimens of this species, both of which are broken at the beak. Together, however, they furnish a fairly complete set of data; and considering the scarcity of fossils other than eurypterids in the Bertie waterlime, we have ventured to describe the species. In outline as well as in the strong development of the concentric folds in front the form is a Rhytimya, and we have placed it with that genus although it lacks the radiating lines of the posterior portion and Rhytimya has so far not been reported from the Silurian above the Richmond.

Goniophora sp.

Doctor O'Connell (1916, p. 87) has cited Goniophora sp. as the representative of the pelecypods in the Bertie waterlime. This citation is corroborated by a small specimen in our collection, that exhibits the outline and sharp posterior ridge of a Goniophora. It is, however, too fragmentary to be described.

X GASTROPODA

Hercynella buffaloensis O'Connell

Plate 15, figures 8 and 9

Doctor O'Connell (1914, p. 93) has described two patelloid gastropods from the Bertie waterlime at Buffalo as Hercynella buffaloensis and H. patelliformis. Neither of the types of the two species is perfect, the apex being missing in all specimens.

We have before us a specimen of the smaller form, H. buffaloensis that retains the apex, The latter is situated one-fourth of the diameter from the anterior margin, rather prominent, the shell being one-third as high as long (10 mm high, 28 mm long). The shorter (frontal) slope is convex, becoming nearly vertical near the margin, the opposite slope is gently concave.

The two species are referred to the Bohemian genus because of the presence of a small sinus on the margin and a corresponding reentrant on the growth lines suggesting a structure similar to the fold characteristic of the genus Hercynella. Doctor O'Connell is aware that the American forms lack the characteristic development of the flexure of the Bohemian types and explains this with the earlier appearance and more primitive condition of the American species, proposing the term " Hercynellina " in case the latter should prove different with the discovery of more and better material in the future.

Our specimen shows but the faintest suggestion of a marginal sinus and reentrant in the growth lines and not any of a flexure. We should have placed the form with Palaeacmaea, especially since it lacks the radiating lines[1] of Hercynella, while exhibiting strong growth lines, but consider it possible that the weak sinus and reentrants will prove such a constant character as to require recognition, together with the slightly asymmetric position of the apex, another character present in much more emphasized condition is Hercynella.

The main interest in our specimen centers in its preservation. Like O'Connell's types in the Buffalo Museum, the shell is preserved as a mere carbonaceous film. This observation has led Doctor O'Connell to the conclusion that the creatures had extremely thin shells, which conclusion again is used to infer, by contrast with the thick shells of the marine Bohemian congeners, a fresh water habitat for the Buffalo Hercynellas. This conclusion, so much desired by the author of the paper, because of their association with the eurypterids, is, however, clearly erroneous. The Hercynellas of the Bertie waterlime had undoubtedly very thick shells, for the following reasons. The thin film is no evidence whatever of a thin shell, because in the same bed occur the numerous specimens of Pristeroceras here described, a Hexameroceras type whose shell was distinctly specialized for protection and is always thick in the Bohemian and our Niagaran rocks. These originally thick shells are also preserved as mere films, since as in the related gastropods the aragonite composing them was easily dissolved. Also Trochoceras and Orthoceras shells are reduced to films, and even Stromatoporas appear as hardly noticeable films, but are still recognizable by the astrorhizae. Nor is the suggested inference (*ibid*, p. 96) that the Hercynellas had entirely corneous (conchiolinous) shells admissible, for such are also better preserved as is shown in the case of the eurypterids.

Another character that disagrees with the supposed original thinness of the shells is the distinct presence of concentric rugae or thick growth lines even in the thin film, suggestive of a former thick shell. Still more is this latter indicated by the very small amount or entire absence of vertical compression in the shells, as clearly shown in our specimen, and which contrasts even with the greater compression of the thick Prionoceras shells and still more with those of the flattened-out eurypterid-skins.

Doctor O'Connell's suggestion that the shells appear, as " though available lime were not abundant in the water in which they lived "

[1] Doctor O'Connell describes traces of such from the type of P. buffaloensis.

is in direct contradiction to that other statement of the same author, that the Bertie waterlime was formed by rivers that carried an abundance of lime (O'Connell, 1916, p. 112, 117.) And to make the circle of erroneous conclusions complete fresh water shells are by no means always thin, for, as the thick-shelled mussels of the Mississippi basin show, the mollusks are perfectly able and willing to make the most of the lime in the river waters (Coker, 1919, p. 15)[1], and of course would have done so with especial satisfaction in that highly limey hypothetical "Bertie river" that carried the eurypterids and deposited the Bertie waterlime.

Loxonema (?) **bertiense** nov.

Plate 15, figure 10.

The Buffalo Museum (No. $\frac{15710}{E2828}$) contains a single specimen[2] of a medium-sized gastropod, from the Bertie waterlime at Buffalo, collected by Mr E. Reinhard. It is much flattened and its substance in the upper portion reduced to a mere film, leaving much doubt as to its generic relations. Owing to the apparent absence of a slit-band, or of its impression, and the oblique shape of the volutions, we refer the form to Loxonema, which already contains similar species from underlying and from younger formations. Grabau (1910, pl. 32, fig. 5) has figured as Loxonema (?) sp. a fragment of a still larger, but otherwise similar form from the Akron dolomite at Akron, N. Y.

The characters of the specimen are as follows: Shell of medium size (length 31+ mm, width 7.5 mm), seven volutions shown. Volutions loosely turreted with very deeply impressed sutures; strongly convex in the younger part, more angular in last volution (through imperfection of preservation ?). Angle of spire about 15 degrees, fairly regular. There are no traces of sculpturing seen.

It is possible that better material would give evidence of a slit-band and of characters bringing the form under Lophospira, which, for example, contains in L. subulatum (Conrad) of the Clinton of New York a type of quite similar slender spire with oblique volutions.

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[1] This paper contrasts the mussel shells of the Atlantic region with those of the Mississippi basin and points out the dependence of the thickness and compactness of the shells (suitable for the button industry) on the lime content of the river water.

[2] Meanwhile another specimen has come to hand that exhibits the same characters.

Hormotoma gregaria Ruedemann

When we (1916, p. 73) described this species, we had only specimens from the lower Bertie waterlime at Marcellus, N. Y., before us. Meanwhile the form has also been obtained in the Bertie waterlime at Buffalo and at Litchfield, Herkimer county. It is there mostly preserved as fine black films only, with low wavy elevations indicating the volutions. One specimen from Buffalo, 10 mm long, consists of nine volutions. The specimens from Litchfield, are smaller, only one-half the size of the others and have grown only to four volutions. They appear to be only the young, or a stunted variation of the species.

XI CEPHALOPODA

Orthoceras sp.

Plate 16, figure 3.

Besides the large Dawsonoceras oconnellae the Bertie waterlime at Buffalo has afforded a second orthoconic cephalopod that was collected by Mr Reinhard. The specimen is here figured. It shows little more than a slowly tapering conch with a narrow, central tubular siphuncle. The septum shown at the end of the conch is quite convex.

Fig. 33.

Figure 33 Outline of living chamber (or distorted septum) of a large unknown cephalopod. Natural size. Bertie waterlime. North Buffalo, N. Y.

The most interesting ture of the specimen is the light brown longitudinal lines, 1 mm wide, separated by wider intervals, similar to the color bands described by Blake of Orthoceras annulatum Hall and by Foerste of Orthoceras trusitum Clarke and Ruedemann (see Ruedemann, 1919, p. 80, 81.). Like the longitudinal color bands of Geisonoceras tenui-

textum (Hall) (*ibid*, p. 82) they seem to become thinner towards the sides and may have been absent on the opposite (ventral) side altogether.

Dawsonoceras oconnellae nov.

Plate 16, figure 2.

The Buffalo Museum contains a large orthocone from the Bertie waterlime of the Bennet quarries in North Buffalo (No. $\frac{11462}{E977}$ of collection) that has been cited as Orthoceras undulatum Hall by Doctor O'Connell (1916, p. 87).

Orthoceras undulatum Hall is a form of the Rochester shale and Lockport limestone that belongs to the group of Dawsonoceras annulatum (Sowerby). Foord (1888, p. 57) has erected for it the var. americanum of D. annulatum. Bassler (1915, p. 388) cites O. undulatum as a synonym of D. annulatum. Whatever the relations of D. undulatum to D. annulatum may be, it is certain that the Buffalo specimen does not belong to either, although it seems to have possessed the undulate surface ornamentation of the Rochester shale fossil. Its rate of growth is considerably more rapid than that of either D. annulatum or D. undulatum. It is about 1 in 7, while that of annulatum is given by Foord (*ibid*, p. 53) as varying from 1 in 10 to 1 in 14 and that of undulatum as 1 in 17 (*ibid*, p. 57). Hall's figures of D. undulatum corroborate this statement. Furthermore, the siphuncle is not central but submarginal in position.

The specimen is a large orthocone, 22 cm long and expanding from a width of 22 mm to 55 mm. The siphuncle is tubular and has a width of 9 mm where the conch is 22 mm wide. It is about 2 mm from the nearest margin. The living chamber was relatively large; it occupies 111 mm in the specimen. The septa were shallow; the depth of the camerae was about one-fifth of the width of the conch (8 mm where the conch is 40 mm wide). The ornamentation apparently consisted on the living chamber of transversal frills such as are seen in D. undulatum; in the earlier part also traces of transverse ribs are observable.

Phragmoceras accola Ruedemann

This large cephalopod from the Bertie waterlime at Litchfield has been fully described before (Ruedemann, 1916, p. 77). Four specimens were figured. Three more have since come to hand from the same locality, which, although fragmentary, suggest the same species.

Trochoceras cf. **anderdonense** Grabau

Plate 17, figure 2.

Trochoceras anderdonense Grabau. Michigan Geol. & Biolog. Survey. Publ. 2. Geol. Series 1, 1910, p. 200, pl. 28, fig. 9, pl. 29, fig. 5, 6.

Mr Reinhard has collected in the Bertie waterlime two coiled cephalopod shells that are too poorly preserved to allow positive determination. So much, however, is certain that they are forms with more widely open umbilicus than Mitroceras gebhardi has, that their volutions were rounded and slowly increasing in size. In all these characters, as well as in their dimensions the specimens agree with T. anderdonense Grabau, a form obtained in the Amherstburg bed of the Monroe formation in the Detroit River in Michigan. According to Grabau's correlation the Amherstburg dolomite and Anderdon limestone correspond to the Cobleskill limestone and Bertie waterlime, so that there is also identity of relative ages.

The second specimen exhibits what appears to be a fragment of a slightly nummuloidal siphuncle on the inner, lower side of a volution.

Pristeroceras timidum gen. nov. et. spec. nov.

Plate 14, figures 1–7.

Description. Conch a medium-sized arcuate brevicone; section of living chamber broadly oval, widest about one-third the median section from the dorsal margin; the median axis about one-fifth longer than the transversal. Siphuncle marginal, tubular, probably ventral.

Final living chamber large and subglobose, occupying one-half of length of conch, curved more on the dorsal side, the strongest curvature being found in the lower third; ventral margin more evenly curved. Aperture in plane sloping distinctly from dorsal to ventral margin. Lateral sinuses of brachial area six in number, very unequal in size, the first very shallow, extending in dorsal direction, the second longest, curved dorsally, the third short and broad, extending obliquely in ventral direction. Hyponomic area consisting of long, narrow slit, the edges of which are provided with distinct serrations, about five on each side, which alternate or interlock; and an oval ventral opening the edges of which form a distinctly projecting spout.

The camerate portion is rapidly contracting and more or less curved toward the ventral side. Camerae very shallow, about 9 times as wide as deep (estimated). Sutures fairly straight transverse. Septa shallow, their depth about equaling that of camerae.

Surface sculpture consisting of growth-lines only.

Measurements. The living chamber of an average specimen (fig. 7) is 33 mm wide in dorso-ventral direction and 35 mm long. The aperture measures 27 mm long, and the base 25 mm in dorso-ventral direction. The length of one specimen (fig. 5) not complete at the apex is 53 mm (living chamber 32 mm); it probably was about 8 mm longer.

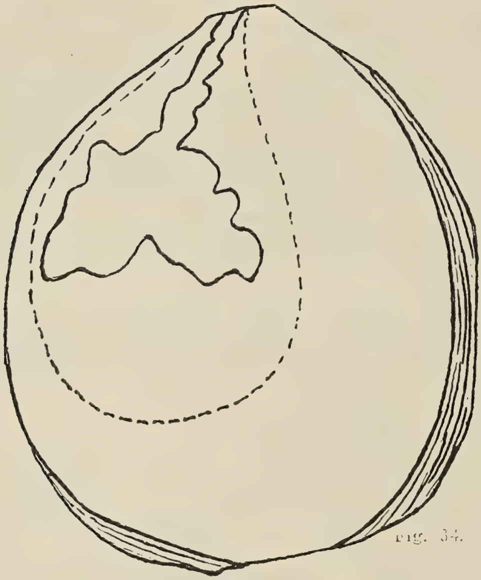

Fig. 34.

Fig. 37.

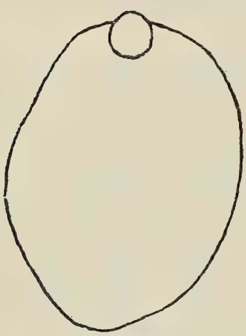

Fig. 35.

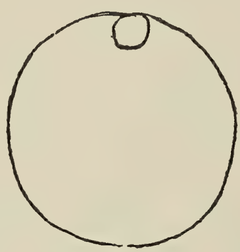

Fig. 36.

Figures 34–37 Pristeroceras timidum nov.

Figure 34 Large specimen obliquely compressed, seen from apertural side, showing aperture and basal outline of living chamber. Natural size. Original in the Buffalo Museum.

Figures 35 and 36 Upper and lower septa with marginal siphuncle, referred to this species. Natural size.

Figure 37 A detached siphuncle, found in the Bertie waterlime and referred to this species.

Horizon and locality. Bertie waterlime, Buffalo, N. Y.

Remarks. The fossil before us invites our interest for various reasons, first as a new representative of the short-lived group of breviconic forms with strongly contracted apertures; then as a cephalopod occurring in the Bertie waterlime where but few other fossils but eurypterids have been obtained; and finally, and this is its most interesting feature, for exhibiting series of teeth in the slit leading to the hyponomic sinus.

We have already (Ruedemann, 1916, p. 80) pointed to the restricted range of the entire group of Trimeroceratidae which in Bohemia occur only in the Middle Silurian and in America in the Niagaran. To the four species of Hexameroceras known before from the Niagaran of Ohio and Indiana, we had there added a species from the Guelph of New York, and one from the Pittsford shale (as Septameroceras (?) sp., probably also a Hexameroceras); and a small Gomphoceras from the Bertie waterlime at Morganville, N. Y.[1]

In a later paper (Ruedemann, 1919), a further species of Hexameroceras was described from the Vernon shale at Pittsford. To this is added now a further form of Hexameroceras from the Bertie waterlime which, however, in the serrate condition of the hyponomic slit presents an important character that sets it off as a still more aberrant type which it is proposed to recognize by the generic term **Pristeroceras.** (Πριστήρ, a saw).

The biologic importance of this character consists in its falling completely in line with the views advanced lately by Prell (see H. Prell, 1921, p. 303; also Ruedemann, 1922, p. 56), on the mode of life of the breviconic cephalopods with contracted apertures. These strongly contracted, more or less lobed and sinuous apertures have been variously, but never satisfactorily explained; the general assumption being that the lobes were the exits of arms and thereby indicative of the number of arms. Professor Prell shows the impossibility of the animals effectively extending arms through the often very narrow slits or if they ever could do so, of bringing any prey to the mouth within the shell. He further shows that the gradual contraction of the aperture which is entirely a feature of maturity and old age finds its exact analogy in certain forms of Helix and such marine gastropods as Cypraea. In these, however, the body of the animal is so plastic during life that it can be readily and wholly extruded with foot and mantle through the narrow slit,

[1]The latter (G. osculum Ruedemann) is cited there as occurring in the Cobleskill limestone. According to recent information from Professor G. H. Chadwick the bed is his Falkirk dolomite.

a feat which seems impossible to one who is only accustomed to see the hardened bodies preserved in alcohol. By comparison with these forms it is concluded that the animals of Phragmoceras (in its older wider sense) also were plastic enough and lacked all cartilaginous cephalic parts, so that they could extrude their entire cephalopodium. They could then easily move, either crawling or swimming, capture and devour prey, and retreat completely for protection within the shell. The apertures of the mature individuals became undoubtedly contracted for protection as in the gastropods mentioned above. It is now a final step, exactly along the development seen in Helix and Cypraea, that interlocking teeth develop when the slit has reached its limit of contraction and the form is still seeking further protection by narrowing the aperture.

Abel (1920, 1924, p. 193) has advanced the alternative hypothesis that the forms with constricted apertures were feeding on microscopic organisms. Such microphagous forms would have no need to thrust out the head and would also, as the recent Dibranchiata using microscopic food, suffer reduction of the fleshy arms.

It is probable that both adaptations, that to extrudibility of the entire cephalopodium and that to microscopic food, may be represented in the various forms with constricted apertures, the latter varying widely between the Hexameroceras and Phragmoceras types. It seems natural that the little offensive microphagous forms would not only need the protection of the constricted apertures, but also the wide expansion of their grasping or, rather, food-inducting organs, made possible by the extrusion of the cephalopodium.

The complete absence of rhyncholites in association with these older cephalopods throws doubt on the supposition that they were such ruthless robbers as many of the recent Dibranchiata and Nautili are.

It is also significant that Pristeroceras timidum occurring in the Bertie is the last representative of the whole family; at least, on this side of the Atlantic. We must therefore infer that the group became either extinct by protective measures carried too far, or else as Steinmann believes, by throwing off their shells altogether, or rather incorporating them completely in the body and finally resorbing them, succeeded in leading to the more recent shell-less cephalopods.

Finally, also the stratigraphic occurrence of this species is interesting enough to be briefly noted. The species occurs in the Bertie waterlime which on account of its eurypterid fauna has been in late years the object of considerable speculation as to its bionomic

conditions. We will recur to this question in another chapter when all new facts are available, and here only state that we have before us remains of about twenty individuals — all from a restricted locality — or too many to consider the occurrence as that of a straggler only, carried out of his marine realm into the upper reaches of a delta.

The specimens here described are all preserved as mere carbonaceous films, as are all cephalopod and gastropod shells, the aragonite of the conchs having been completely dissolved in the Bertie waterlime beds. The specimens represented in figures 4–7 are moreover so completely flattened that the original section could not be made out from them and has to be inferred from the vertically compressed specimens (text figure 34), and from the septa (text figures 35, 36) whose reference to Pristeroceras timidum, however, is not beyond doubt. Notwithstanding the fragile preservation of the specimens, their general shape, the strong impressions of growth lines and the condition of their known relatives in other localities, all indicate that they were originally furnished with thick-walled, compact shells.

Mitroceras Hyatt

Hall (1852, p. 335) proposed the generic term Trochoceras for two species of cephalopods of the Coralline limestone (now Cobleskill limestone) of Schoharie, N. Y., namely, T. gebhardi and T. turbinatum. The name was preoccupied, for Barrande had already erected a genus Trochoceras in 1848, but both authors "courteously acknowledged each other," as Hyatt (1894, p. 503) states, and henceforth called the genus Trochoceras, Barrande and Hall. Nevertheless it is obvious that the Bohemian and American forms united by these authors are not congeneric, and Hyatt has therefore distinguished the two American types as Mitroceras, with M. gebhardi as genotype.

The types of both species, M. gebhardi and M. turbinatum (holotype in the case of the second species) are preserved in the New York State Museum together with a number of additional specimens.

A study of this material shows readily that the two species can not be congeneric, for one has a low trochiform outline (M. gebhardi, see text figure 38), while the other has a high turbinate one (M. turbinatum) and likewise the sections of the volutions differ. Hall recognized this difference between the two in defining his genus as being "turbinate or trochiform" adding that the "spire is elevated, more or less ventricose" and Hyatt's name Mitroceras must have been given under the impression that

the genotype *gebhardi* had also a high mitriform shape such as turbinatum has.

Bassler in the Bibliographic Index (1915, vol. 2, p. 1297) has, in recognition of the difference between the two species, retained turbinatum under Trochoceras. A comparison with Barrande's genotype of Trochoceras (T. davidsoni) shows, however, the wide difference between the high, adjoining volutions of turbinatum and the subcircular, free volutions of davidsoni.

Both American forms are remarkable fossils of unique shape. They represent a development of the torticone to a degree not known in any other Paleozoic formation, and only duplicated, by later parallelism, in the torticones and turriliticones of the Cretaceous ammonites. It is an aberrant attempt of the early nautiloids to a contraction of the shell into a narrower space by coiling in a close spiral curve and this contraction is carried so far that a distinct impressed zone and sharp angulation of the upper and lower margins of the volutions result in gebhardi.

The genus represented by the single species turbinatum and differing from Mitroceras, as known in M. gebhardi, in the much higher elevation and development of the spire we propose to name "Foersteoceras," embracing this occasion with pleasure to connect the name of one of the most untiring students of the Silurian stratigraphy and paleontology of North America with this unique and interesting form.

Hyatt did not define his genus Mitroceras, except by stating that the two Cobleskill forms are quite distinct from Barrande's Trochoceras and designating Trochoceras gebhardi as the genotype.

Mitroceras, as here restricted, is characterized by trochiform spiral volutions forming a low torticone whose volutions are in section about as wide as high, semicircular on the outside and subquadrangular on the inside, with sharp angles on the under and upper sides. The upper inner side which is in contact with the next volution is flat. The location of the hyponomic sinus cannot be directly observed as the growth lines are poorly preserved, but it is fairly safe to assume that the shell was carried with the volutions standing upright, in which case the hyponomic sinus and funnel were on the outer margin. Nor can the location of the siphuncle be directly observed, owing to the destruction of the inner structure. The sharp bending backward of the sutures on the outer angle indicates a ventral location (on the outside in this case) of the siphuncle, and

a trace of a siphuncle on the outer side of the second (upper) volution in the type specimen agrees with this inference.

Foersteoceras possesses a high mitriform or turbinate torticone, whose volutions are higher than wide, rounded both on the ventral (exterior) and dorsal (inner side) and possessing but a slight angulation along the upper side.

Both Mitroceras and Foersteoceras are similar in their general structure, notably the torticone mode of volution and clearly represent a development in the same direction, in which Mitroceras has gone a step farther than Foersteoceras, in the consolidation of the volutions to such a degree that a distinct impressed zone and bounding keels are formed. It is obvious that this aberrant development took place in response to some peculiar adaptation of the form. The Cobleskill limestone in the Schoharie region is a distinct coral reef formation, in some places the beds being entirely composed of large colonies of Favosites, Prismatophyllum and Stromatopora. It is therefore legitimate to consider the two cephalopods as members of a coral reef fauna. They are associated with species of Phragmoceras, Oncoceras and thick-shelled Murchisonias, which likewise suggest life on a coral reef. It is probable that these solid, contracted cephalopod shells were better able to move about between the coral stocks and to retain their hold in the turbulent waters.

Mitroceras gebhardi (Hall).

Plate 19, figure 2.

Description. Conch a low, trochiform dextral torticone, (apical angle about 155°, conjectural) about twice as wide as high. Four to five volutions, which increase about two-fifths of their diameter in one whorl, are subquadratic in section, the outer side being rounded, the inner lower side gently convex, the upper gently concave; the margins between the inner and outer sides distinctly angular or slightly keeled, the inner angle less acute. Volutions in contact only with the middle of the lower exterior, respectively inner upper sides, forming a wide umbilicus between them.

Living chamber large, occupying one whorl or more. Aperture unknown. Septa closely arranged, sutures strongly curved, with broad, low, external saddle and narrow, angular saddles on the keels, with broad, flat lobes on the two inner sides.

Siphuncle incompletely known, apparently small, slightly nummuloidal, submarginal on middle of outer (ventral) side. Surface furnished with growth lines and some deeper constrictions. Hyponomic sinus shallow, on exterior side of volution (exogastric form).

Measurements. The type specimen (plate 20, figure 1) no. 12566 ——— of Museum catalog, measures 115 mm across the base; the height of the two last volutions is about 48 mm; the entire height was about 60 mm. The greatest width of the last volution, which is not perfect, is 38 mm and the height 38 mm (probably originally slightly more). The sutures on the penultimate whorl are 3 mm apart, the siphuncle is there 2.5 mm wide.

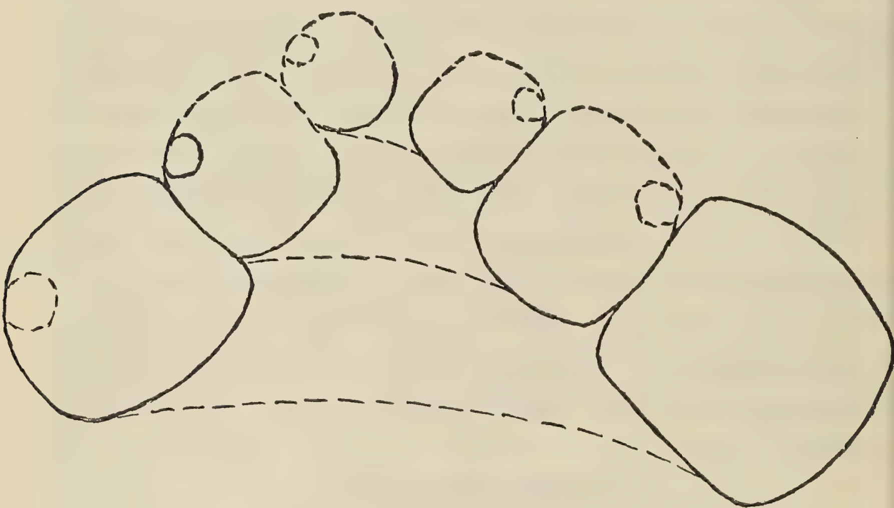

Fig. 38.

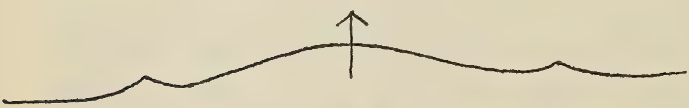

Fig. 39.

Figures 38 and 39 M i t r o c e r a s g e b h a r d i (Hall).
Figure 38 Natural section seen in type specimen. Natural size.
Figure 39 Suture line of same.

Horizon and locality. Cobleskill limestone at Schoharie, N. Y.

Remarks. M i t r o c e r a s g e b h a r d i is cited in Bassler's Bibliographic Index, as occurring at Buffalo, Williamsville and Akron, N. Y. This reference is on the authority of Professor Grabau, who identified a specimen collected by Messrs Vogt and Piper with the Cobleskill species. The specimen (see plate 21, figure 2) which has been cited and figured in various publications (see Grabau 1900, pl. 21, figures 30, 36; 1901; figure 149; 1906, figure 17; 1900, a pl. 31, figures 3*a*, 3*b*. 1910 *b*, figure 1290) is certainly not a

Mitroceras gebhardi, if we correctly understand the form, but may be a young individual of Foersteoceras turbinatum. The fact, however, that it lacks all traces of septa leaves its cephalopod nature doubtful. This specimen came from the "Bull-head" rock (Akron dolomite) and has been considered by Professor Grabau as important in the correlation of that bed with the Cobleskill limestone.

The State Museum contains five fragments of volutions of a form from the Bertie waterlime at Buffalo that have the character of those of Mitroceras gebhardi, as far as their much compressed condition allows of an identification. These have also been mentioned by Professor Grabau (1900, p. 371.). One of them, at least, shows the septa (see plate 17, figure 1) and their association in the Bertie waterlime rock with eurypterids is proved by the occurrence on the same small slab of a whorl and two segments of Eurypterus lacustris.

Foersteoceras turbinatum (Hall)

Plate 19, figure 1; plate 20, figure 1; plate 21, figure 1

Description. Conch a high mitriform, dextral torticone (apical angle about 55°), width to height as 2:3. Five or more volutions, which increase by about one-fifth of their diameter in one whorl, subelliptic in section, with a slight flattening on the upper inner side, along the contact of the whorls, the remainder of the inner side being well rounded as is the outer side of the whorl. Umbilicus large.

Living chamber apparently large, not known in full extent. Aperture unknown. Septa closely arranged, relatively deep (one-fourth as deep as wide), evenly convex. Sutures not distinctly seen.

Siphuncle fairly large, slightly nummuloidal with secondary deposits, situated marginal and below the strongest projection of the outer side.

Growthlines strong, irregular in size, swinging in sigmoidal curve across the outer side. Hyponomic sinus not distinctly seen.

Measurements. The holotype (Hall, plate 77, figure 1) with four volutions preserved measures 14 cm in height. Complete it would have measured about 19 cm and been 13–14 cm wide at the base, consisting of six or more volutions. The umbilicus is not quite half as wide as the basal diameter (about 6 cm in the holotype; conjectural). The siphuncle is about 5 mm wide in the last volution.

Horizon and locality. Cobleskill limestone at Schoharie, N. Y.

Remarks. The material before us representing this species consists besides the holotype of four specimens, one a larger individual than the type, preserving a septum on the right lower side,

another preserving well the cast of the siphuncle; and another one the small impressed zone. The type specimen itself shows besides the outline of three volutions the cast of the inner side of the last whorl and a cast of the siphuncle. Also an outline of the section of the third volution, that is bodily preserved, is seen on the side. The shell was evidently fairly thick, as is indicated by the shell fragments preserved on the type specimen.

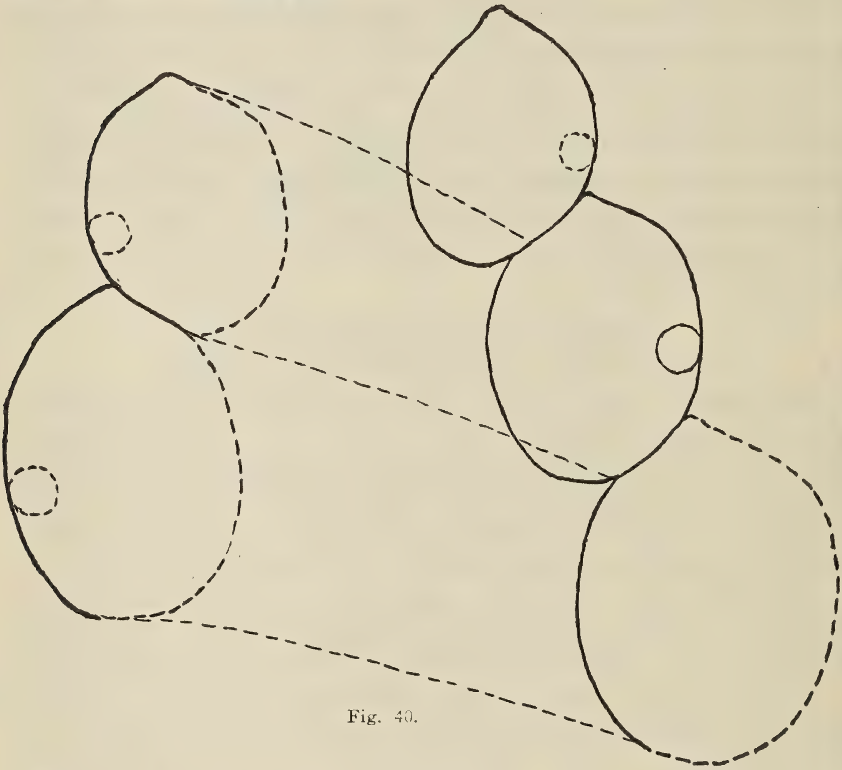

Fig. 40.

Figure 40 Foersteoceras turbinatum (Hall) Section of type specimen. x 4/5.

XII CONULARIDA

Tentaculites sp.

A fragment of a large Tentaculites (width 4 mm) was found in the Gasport lens of the Lockport limestone. The transverse ridges are sharply projecting and number 11 in 10 mm. The interspaces show equal longitudinal striae, which however, do not seem to pass over the transversal ones. There is no species of that character known from the Lockport limestone.

Conularia niagarensis Hall

While Spencer and Derby found in the Lockport limestone at Hamilton a variation of C. niagarensis that has coarser ridges, we have before us seven specimens of a Conularia, from the Gasport lens of the Lockport limestone, that bear the characteristic niagarensis sculpture, but have the ridges markedly finer and more closely arranged. The ridges number 26–28 in 1 cm in one specimen, and are almost always above 20 in that interval, as against an average of 16 in niagarensis; although their number may sink in spots to 16. The size of these specimens is only half that of the niagarensis of the Rochester shale; the largest specimen observed does, not completed, reach 7 cm in length; and when compared with young specimens of niagarensis, it becomes apparent that the apparent difference in fineness of sculpturing is largely but one of relative age.

Conularia niagarensis var. **rugosa** Spencer

Conularia rugosa Spencer. Bul. Missouri State Mus., I, 1884, p. 59, pls. 8, 9, figs. 2, *2a*; Trans. Acad. Sci. St Louis, 4, 1884, p. 608, pls. 8, 9, figs. 2, *2a*; Bassler, U. S. Nat. Mus. Bul. 92, 1915, p. 275; Dyer, Trans. Roy. Soc. Canada, section IV, 1921, p. 65, 66, pls. 1, 2.

Spencer has described as Conularia rugosa a medium-sized form from the Lockport limestone at Hamilton, Ontario. More recently the species has been more fully described from better material by Dyer.

A comparison of C. rugosa with the common C. niagarensis Hall, which is most common in the Rochester shale, but also enters the lower Lockport limestone (according to Hall) brings out the fact that the general outline, angulation and sculpture are identical, the only difference that can be noted resting in the somewhat coarser arrangement of the transverse ridges. Spencer records ten ridges in 1 cm; Derby's figure shows variations from 10 to 14 in 1 cm. In C. niagarensis there are about 16 in 1 cm. in an average or typical specimen; but their number varies greatly so that 10 to 24 could be counted in one specimen in different places.

It would therefore seem that C. rugosa could be hardly more than a variety of C. niagarensis.

Conularia cataractensis nov.

Plate 22, figure 7.

Description. Shell of medium size, apparently thin, tapering uniformly except in apical portion where the rate of growth is more rapid. Cross section apparently broadly rhombic. Faces equal,

moderately convex; apical angle of mature portion 35° to 40°. Marginal grooves deep, without prominent margins; facial groove very faint or absent. Aperture not known. Apex blunt. Apical septa unknown. Surface marked by very fine, sharply raised, threadlike ridges, numbering 40–50 in 1 cm separated by equal intervals, straight and meeting along the facial line in a distinct, wide angle (140°). The lines bear extremely minute prominent tubercles, numbering 4 in 1 mm. The intervals are smooth.

Measurements. Length of holotype 45 mm; greatest width (incomplete) 20 mm.

Horizon and locality. Whirlpool sandstone member of Cataract formation (Silurian); Niagara river gorge.

Remarks. Only one specimen is available of this species; an impression, which, however, retains the sculpture beautifully preserved in spite of the rather coarse grain of the rock. The extremely fine character of the sculpture, the closely crowded ridges will serve to distinguish this species from the Silurian congeners, save C. tenuicosta from the Gasport lens of the Lockport limestone which however, is still slightly coarser in ornamentation, slenderer in shape and possesses cross lines in the furrows.

Conularia tenuicosta nov.

Plate 22, figures 1–3

Diagnosis. Shell of medium size, very thin, noncalcareous, tapering uniformly, cross section square (?); faces equal, flat or but slightly concave; apical angle about 20° to 25°. Marginal grooves well defined; deep, with prominent, sharp edges. Central facial grooves faint. Aperture wide open, surrounded by low, rounded lobes. Apex bluntly pointed; apical septa unknown. Ornamentation consisting of fine, closely packed ridges (80–150 in 1 cm); arched gently across each face, meeting at a wide angle and without break in the marginal grooves and the central facial line; studded with small round tubercles. Furrows with fine lines connecting the tubercles of the ridges; smooth in some places.

Measurements. Length 5 cm, width of face 12 mm.

Horizon and locality. Gasport lens of Lockport limestone at Gasport, N. Y.

Remarks. We have four complete specimens of this beautiful Conularia before us, two of which are connected with their apices. The exact mode of attachment is not clearly visible, but presumably by a small attachment disk, such as we have described of C. gracilis Hall, (Ruedemann, 1896, p. 158 ff.). In the fine group of radiating specimens (Slater, 1907, pl. 2 fig. 1) of C. tenuis

Slater such fixation disks are seen scattered over the center of the group. In another group of two fragmentary specimens of C. tenuicosta (see plate 22, figure 3) connected at the base, the impression of a disk can be distinctly seen. It lacks however, all chitinous substance.

There also occurs another mode of attachment in Conularia. Some 20 years ago the writer saw in the large collection of the late Frederick Braun in Brooklyn, N. Y., a magnificent group of gigantic Conularias, obtained by Mr Braun while collecting crinoids for Doctor Springer in the western Mississippian, that were attached to a common center by a finely preserved byssus. Unfortunately the Braun collection has not yet been acquired by any institution and this valuable specimen may become lost to science.

Conularia tenuicosta is readily distinguished from C. niagarensis by its slender form and extremely fine ornamentation.

Conularia filicosta nov.

Plate 22, figure 4

Description. Shell small, rate of growth diminishing toward aperture, giving shell a curved appearance. Cross section probably square. Relative sizes of faces not known. Faces gently concave; apical angle 20°. Marginal grooves deep, with prominent margins; facial groove only noticeable in apical portion. Aperture and apex not known. Surface marked by very sharply raised, threadlike, sometimes bifurcating ridges; numbering 25 in 10 mm, separated by intervals twice the width of the ridges; meeting at an angle of 130° and bent forward along the facial line. Intervals between ridges smooth.

Measurements. Length of holotype 26.5 mm; greatest width 12 mm.

Horizon and locality. Rochester shale, Niagara river gorge.

Remarks. This species in general character of sculpture is similar to Conularia bifurca Ringueberg (1886, p. 18): the latter, however, although known only in a fragment has clearly much more closely spaced ridges (20 to 1/8 inch or about 64 in 10 mm).

The ridges where fully preserved appear as black filiform bodies, resting on the surface of the shell.

Conularia perglabra nov.

Plate 22, figures 5 and 6

Description. Shell small to medium size; thin, slightly tapering more rapidly at the apex. Cross-section probably rhombic. Faces equal or nearly so; flat to very gently convex; apical angle of mature

portions about 20°. Marginal grooves narrow, but deep, without prominent margins; facial groove broad, flat, marked by two sharp lines. Aperture wide open, bounded by large triangular lobes. Apex and apical septa unknown. Surface smooth, faint growth lines the only ornamentation.

Measurements. Length of type specimen 38 mm; complete about 45 mm; width of face 11 mm.

Horizon and locality. Bertie waterlime, North Buffalo, N. Y.

Remarks. We have two specimens of this peculiar form. One, the type, here described, is a normal straight Conularia shell; the other, however, is larger and flaring out towards the aperture in a manner not known to us from other conularias.

The smooth surface is the best distinguishing character of this species.

Serpulites corrugatus nov.

Plate 15, figure 11

Description. Tube large, attaining a width of 8.5 mm, fairly rapidly expanding (in a length of 30 mm from 7 mm to 8.5 mm), of unknown length. Marginal welts sharply defined, thick and prominent (.8 mm wide). The body of the tube formed by a thin chitinous test that is densely wrinkled longitudinally, looking like tissue paper.

Horizon and locality. Rochester shale, Niagara river gorge.

Remarks. The writer had occasion to describe a number of species of Serpulites, mostly from the Ordovician, in New York State Museum Bulletin 189. To these is added here a large type from the Rochester shale, that is remarkable for its sharply defined lateral welts and the intense wrinkling of the thin test. In its dimensions the Rochester form recalls S. longissimus Murchison, the genotype and well-known British Silurian form. It differs, however, from the latter in its thinner test, which in S. longissimus appears transversely plated as in S. lumbricoides Ruedemann, a Trenton form, instead of being closely wrinkled longitudinally.

Serpulites sp.

The presence of a species of Serpulites in the Bertie waterlime is indicated by chitinous-phosphatic welts of the tubes about 1 mm apart. The form seems to have been a small and very slender one, similar to an undescribed species of the Clinton shales.

XIII CRUSTACEA

Ceratiocaris acuminata Hall

Plate 16, figure 1

Hall (1859, p. 422) described this large Ceratiocaris from a carapace found in the Bertie waterlime at Buffalo. Later a whole specimen was described and figured by Pohlman (1886, p. 28) as coming from the same formation and locality; and still another complete specimen in the Buffalo Museum of Natural History was figured by Grabau (1901, p. 227). The New York State Museum contains an equally perfect large specimen, here figured, and a telson,[1] dorso-ventrally compressed, that indicates an individual nearly a foot long.

It appears from these specimens that this large phyllopod crustacean possessed a bivalved carapace of somewhat variable outline (which however may be partly due to preservation), which in general was subtrapezoidal, the longer (antero-posterior) diameter of which is a little more than twice the height of the carapace valve (as seen in compressed condition). The median (dorsal) line is nearly straight, slightly convex, gently converging to the mucronate anterior point of the carapace. The ventral margin is strongly convex, forming in the anterior nearly straight half an angle of about 50° with the general dorsal line, then bending fairly sharply and converging gently towards the subtruncate posterior margin. The latter is gently incurved, receding forward and upward. A rostrum has not been seen in any specimen. Gastric teeth are observable in the specimen figured by Grabau and the one in the New York State Museum. They are situated one-fifth of the length from the anterior extremity and a little nearer to the ventral, than the dorsal margin. Ocular nodes have not been seen.

There are five segments visible outside of the carapace and more or less distinct outlines of two more inside the carapace. The last of these is twice as long as the preceding ones. The three caudal spines consist of the long, aculeate telson, which bears a median ridge, and the two flat lanceolate cercopods, about five-sevenths the length of the telson.

The surface is provided with very fine, raised longitudinal lines, which towards the ventral side may become coarse enough to be seen with the naked eye. On the segments there are transversal lines, which on the anterior exposed segments are straight transversal, on the posterior ones become wavy and are restricted to the anterior portions (see plate 21, figure 1).

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[1] A similar telson was figured by Stose (1894, p. 371).

The specimen figured by Pohlman measured 7 inches in length, Grabau's type and the specimen in the New York State Museum measure 8 inches in length. An abdomen in the State Museum, preserving four segments and the caudal spines measures 6 inches and the entire specimen must have measured about 11 inches.

Horizon and locality. Bertie waterlime at Buffalo.

Ceratiocaris maccoyana Hall

Hall (1861, p. 421) has distinguished three species of Ceratiocaris from the Bertie waterlime at Buffalo. The best known of these is Ceratiocaris acuminata. C. maccoyana is based on five specimens, only one of which, showing the carapace (*op. cit.* plate 84, fig. 2) is of diagnostic value.

This is distinguished from that of C. acuminata in having the greatest width and convexity in front of the middle line of the carapace and a width which is one-half the length of the carapace.[1] The carapace is thus relatively shorter or wider, a relation that also expresses itself in the greater angle (about 60°) formed by the dorsal and anterior ventral margins of the carapace.

No further specimens except those described by Hall have become known and the species is still incompletely known. It is entirely possible, that larger collections in the future will prove that the two species C. acuminata and C. maccoyana grade into each other, or that the differences are those of sex.

Ceratiocaris aculeata Hall

Another Bertie waterlime species described by Hall (1861, p. 422) is Ceratiocaris aculeata. Since, however, it is based only on a penultimate segment with the caudal spines and the type is not available, the species is doubtful. Hall saw its diagnostic characters in the broader basal portion and the strong groove of the telson spine, and the strong striation of the test of the penultimate segment. The relative bluntness of the telson spine is, however, quite possibly due to the younger age of the individual, indicated by the small size of the appendage; and the median ridge of the telson spine, as well as the strong striations of the segments are also present in C. acuminata and other species.

[1] These relations are obtained from the figures of the types, the latter themselves being at present not accessible in the American Museum of Natural History.

Ceratiocaris (Limnocaris) clarkei nov.

Plate 23, figures 2–4

The State Museum contains three remains of Ceratiocaris which were all collected in one drift block of Bertie waterlim at the Woodlawn Cemetery at Canandaigua, N. Y., by Doctor Clarke. One is a "mandible" (gastric teeth), another a cercopode and the third is a carapace with five projecting abdominal segments.

The latter proves to represent a new form, different from the preceding species in the relative shortness, or greater width of the carapace. This difference finds its most distinct expression in the ventral margin, which is decidedly more convex than that of either C. acuminata or maccoyana. The width of the valve (26 mm) as compared to the length (46 mm measured diagonally) is greater by one-eighth of the length than half the latter, while in C. acuminata it is smaller than half the length and in C. maccoyana about equals it. The dorsal margin is remarkably straight, except the frontal fourth which bends more sharply than in the other species to the anterior point. The ventral margin, as stated before, is distinctly more convex, the bulging becoming more marked by the stronger contraction of the posterior half of the valve. Also the posterior margin is more strongly incurving than in the two associated species. In accord with the generally more contracted appearance of the form is the relatively short abdomen, which is 30 mm long, and contracts in that length from a width of 12 mm to one of 5.5 mm at the distal end of the penultimate segment or by more than one-half. Its relative contraction is thus greater than that of C. acuminata where it contracts by one-third only, but may agree with that of C. maccoyana, if the original of Hall's figure 3 belongs to that species.

The surface sculpture is the same as in the other species.

There is a distinct eye node observable as a circular depression (the valve being seen in the mould), which would bring the form under Limnocaris (see Clarke, 1901, p. 93), if the absence or presence of that node is to be recognized as a generic difference.

Ceratiocaris (Limnocaris) praecedens Clarke

Doctor Clarke (91, p. 92) has fully described this stately crustacean which was found in the Pittsford shale in association with the eurypterids. It resembles in the form of the carapace the later C. acuminata Hall, but possesses a clearly defined ocular spot and has for that reason been placed in a subgenus Limnocaris.

Later collections have furnished little that would add to the

original description, except a "mandible" and which judging from its size may well have belonged to this species if not to an unknown crustacean. It is preserved in section which brings out the remarkable sharpness of the cusps of these gastric teeth and their "dendroid" structure, showing a central solid axis, upon which rests vertically a fibrous or blocky substance of dark color and phosphatic appearance. The basal portion of the mandible is obviously not fully preserved.

Ceratiocaris deweyi Hall

Hall described this form first as Onchus deweyi (1852, p. 320), considering it a fish spine, but corrected his error in 1859 (p. 83) when he recognized the fossil as the telson spine of a crustacean and tentatively referred it to McCoy's new genus Ceratiocaris. Grabau (1901, p. 227) suggests bringing the fossil under Phasganocaris Novak, proposed for Lower Devonian abdomina and spines of Bohemia, with scaly surface and spinose edges. Jones and Woodward (1888) have described and figured a number of species, as C. murchisoni and C. gigas, bearing exactly the same sculpture as C. deweyi, from the lower Ludlow.[1]

Strangely enough also more recent collections seem to have afforded only the picturesque telson spines. These are found in the Rochester shale, where Hall's original specimen came from. Grabau (1901, p. 228) records them also from the Lockport limestone at Niagara.

Emmelezoe minuta nov.

Plate 24, figure 4

The presence of the rare crustacean genus Emmelezoe in the Bertie waterlime is attested by a single small carapace, 4 mm long and 2 mm wide. Its outline is pod-shaped, the anterior extremity broadly rounded, the posterior subtruncate; the dorsal margin slightly divergent in the posterior two-thirds, then turning rather sharply downward; the ventral margin fairly evenly and slightly convex; except in the anterior region where it converges towards the anterior

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[1] It may be mentioned here that the spine figured by Jones and Woodward together with the spines just mentioned of Ceratiocaris (*op. cit.* pl. 5) as Xiphocaris ensis (Salter) and which is made the genotype of their new genus Xiphocaris (Jones and Woodward, 1886, p. 233) is undoubtedly the telson spine of an Eusarcus, and therefore referable to the eurypterids. This is especially clear from the subrhomboidal section (*ibid.* fig. 7*b*), the scarlike surface sculpture and the peculiarly notched etches (figures 7*c*, 7*d*), all features well exhibited in all telson-spines of Eusarcus. The term Xiphocaris becomes then a synonym of Eusarcus (a name proposed in 1875).

extremity. The ocular tubercle is distinct and close to the dorsal margin. The cordlike rim of all margins, except the dorsal one, is noticeable, although not very prominent. The surface sculpture consists of subparallel, somewhat wavy, longitudinal lines, numbering about 16.

Horizon and locality. Bertie waterlime at Buffalo.

Remarks. There has hitherto been described but a single species, E. decora Clarke from American rocks (Clarke, 1901, p. 95). This came from the Pittsford shale at the base of the Salina beds, and like the Bertie waterlime species is associated with the eurypterids. Although much larger it is very similar in outline to our species and quite probably a direct ancestor of the latter. Judging from the single carapace before us, the Bertie waterlime form would differ, besides being only one-third to one-fifth the size of the other, in being relatively more elongate and more acute anteriorly. The accurate distinction of our species awaits, however, the collection of fuller material. Meanwhile, the find is mainly of interest as adding another crustacean member to the peculiar Bertie waterlime fauna. In Great Britain the genus is represented by three species, all Upper Ludlow forms.

Anomalocaris(?) **kokomoensis** nov.

Plate 23, figure 6

The State Museum received, from the Kokomo waterlime at Kokomo, Ind., among a series of eurypterids, a fossil that had been considered by the collector as a leg of Dolichopterus, but which proved to be a problematicum that probably has no relation to the eurypterids. It bears, however, a striking resemblance to the strange fossil that has been described and figured as the abdomen of Anomalocaris canadensis by Whiteaves (1892, p. 205) and Walcott (1908, p. 246), and may be therefore tentatively referred to that still little known genus of early crustaceans.

It consists of a series of fairly distinct segments, about 17 in number, forming an abdomen that is about 60 mm long, and 10 mm wide at the proximal end, tapering somewhat irregularly to one or several caudal spines. The segments, which are completely flattened, appear subtrapezoidal, with the broader side upward and the height a little greater than the base in the middle segments, but about 3 times greater in the anterior ones. The appendages are hooklike bent in the proximal portion, and straight or but slightly curved backward in the distal portion. They are of about the same length throughout, except the last ones. In several of the first appendages there are indications of branching near the bases.

The fossil, not very favorably preserved and known only from a single specimen, is of interest mainly on account of its occurrence in the Kokomo beds in association with the eurypterids. Its nature is wholly problematical and it is even possible that it belongs with the filamentous appendages of unknown connection with the eurypterids, described by Clarke and Ruedemann (1912, p. 314) from the Shawangunk grit, and which offer a suggestion of similarity with the supposed combs of the Carboniferous Glyptoscorpius as described by Peach.

Lepidocoleus reinhardi nov.

Plate 23, figure 5

Diagnosis. Shell of large size (60 mm long, 10 mm wide, composed of more than 18 (probably 21) plates in a column. Plates about 3 times as wide as long on exposed part (not counting overlap). Amount of overlap and surface sculpture unknown.

Horizon and locality. Bertie waterlime at Williamsville near Buffalo, N. Y.

Remarks. This species is based on a single specimen, which is only a cast of the interior of one row of plates; a small part of this row is broken out. It would, on account of this imperfect preservation, hardly invite description, were it not for the reason that there are so few species of that genus known and each again by but one specimen, so that each new find is worth recording: and moreover that this type was obtained from the Bertie waterlime which before has rarely afforded anything but eurypterids; and finally that the specimen contrasts with its congeners by its large size and great number of plates.

The fact that only the interior cast is present prevents the observation of the exterior sculpture and of the amount of overlap of plates, only the posterior margins of the plates being seen.

The outline of the specimen, which is bent upon itself with the ventral side outward, is elongate blade shaped, the length being 6 times the width, and the margins are fairly parallel, with a very slight contraction toward the base and a gradual one towards the acutely triangular terminal plate. The plates appear closely arranged and relatively short, but they may have overlapped by as much as one-half their lengths as in some of the other species.

The posterior margins of the plates are sigmoidally flexed, in basal direction on the dorsal or "fixed" side and more strongly in apical direction on the ventral side. The ventral margins of the plates are straight. The flexed basal plate is apparently not completely preserved. The impression of the plates is concave along

the ventral margin, gently convex upon the middle and sharply convex and bent down on the dorsal side giving the impression that the plates may have possessed considerable thickness and been thinner along the ventral margins. The subcircular muscle-scar observed by Withers (see *postea* p. 654) near the middle of the inner surface of each plate is recognizable in the larger lower plates in a small subcircular elevation a little towards the dorsal side from the median line.

Since the erection of the genus by Faber for a Cincinnati specimen, there have become known beside the genotype L. jamesi (Hall and Whitfield), two species from the New York rocks, namely, L. sarlei Clarke from the Rochester shale at Rochester and L. polypetalus Clarke from the New Scotland beds (Lower Devonian) of Albany County (J. M. Clarke, 1896, p. 137); each known in only one specimen; one species L. illinoiensis Savage from the Upper Oriskany of Illinois (see Savage, 1913, p. 149), one species from the Ordovician (Trinucleus shale) of Sweden (L. suecicus Moberg, see Moberg 1914) and one from the Upper Ordovician of the Girvan district in Scotland (L. grayae Withers, see Withers 1922), the last two known only in one or two fragmentary specimens. Bather (Bather, 1914, p. 559) in reviewing Moberg's paper mentions also a large form detected by Mr Withers among the Wenlock fossils of the British Museum and one from the Middle Devonian near Olmütz, Moravia, both of which are as yet undescribed. To these is added another record of an undescribed species from Bohemia by Withers (1915, p. 121).

The complete list of the species is hence as follows:

Lepidocoleus jamesi (*Hall and Whitfield*), Cincinnatian, Ohio
- L. suecicus *Moberg*. Trinucleus shale, Sweden
- L. grayae *Withers*. Upper Ordovician, Scotland
- L. *sp.* undescribed ("Squamula bohemica" Barrande, on label) Ordovician, Bohemia.
- L. sarlei *Clarke*, Rochester shale (Silurian), New York
- L. *sp.* undescribed. Wenlock, England
- L. reinhardi *Ruedemann*. Bertie waterlime, New York
- L. polypetalus *Clarke*. Lower Devonian, New York
- L. illinoiensis *Savage*, Middle Devonian, Illinois
- L. *sp.* undescribed, Middle Devonian, Moravia.

While more or less complete specimens are extremely rare, it would seem that detached plates are common or even abundant, especially those of L. jamesi. It is, however, quite certain that a variety of plates from various Ordovician beds of America have been referred rather loosely to this species, especially by the present writer. These, on closer study will probably prove to represent new

species of Plumulites and Turrilepas, such as have been described from detached plates by Moberg from Sweden and by Withers from Esthonia (Withers, 1921).

L. reinhardi seems to be distinguished readily from all congeners by its much greater size and greater number of plates in each column. It is especially distinct from the other Silurian form of New York, L. sarlei Clarke in having 18+ (20) plates as against 12 and 13 in the latter. It is also nearly thrice as large and the plates differ much more in relative size, those of the apical portion being much smaller than the basal ones, in the Bertie waterlime form. In the large number of plates L. illinoiensis from the Clear Creek (upper Oriskany) chert in Union county, Illinois, comes nearest to our form; Savage having counted 17 plates on one and 13 on the other side, neither side being complete. It is also larger than the congeners except L. reinhardi which is still twice its size.

We can not consider here the difficult question whether these forms are really Cirripedia, a question raised by Withers (1915, p. 121 ff.), who points out that we know nothing of the relation of the animal to the shell, and that "except for the ornamentation and the downward growth of the plates there seems to be no other character advanced in favour of their reference to Cirripedia"; while on the other hand, Jouleaud (1916, p. 7 pp.) in his essay on the general evolution of the primitive and pedunculate Cirripedia with calcareous shells would unite the genera Lepidocoleus, Plumulites, Turrilepas and Strobilepis under the term "Proto-cirripedia" as the true ancestors of the pedunculate Cirripedia.

Leperditia alta (Conrad)

Some strata of the Bertie waterlime are entirely covered with a poorly preserved, crushed ostracod, that in general outline and dimensions agrees with L. alta (Conrad). Indeed has this species been cited from the Rondout waterlime of New Jersey by Weller (1909, p. 259) and the Bertie waterlime by O'Connell (1916, p. 87).

The larger form, that is common in the overlying "Bullhead" (Cobleskill) limestone, is the L. scalaris (Jones). It has been repeatedly figured by Grabau (see Bassler's Index, p. 705.).

Besides the larger Leperditias also smaller ostracods were observed. They are, however, undeterminable since the shells are not preserved. The most notable among them is an elongate cylindric form, about 1 mm long.

Leperditia scalaris (Jones)

Leperditia scalaris is a common and characteristic fossil of the Cobleskill limestone in eastern New York and of the corresponding Akron dolomite of western New York. Several fine examples of this stately ostracod have also been obtained in the Bertie waterlime of North Buffalo.

XIV ARACHNOIDEA

Bunaia woodwardi Clarke

Plate 24, figures 1–3

Bunaia woodwardi Clarke. Geol. Mag. N. S. Decade VI, VI, p. 531–2, 1919.

Bunaia woodwardi Clarke. N. Y. State Mus. Bul. 219, 220, 1921, p. 129–31, pl. 1.

This remarkable merostome, a vicarious genus of the well-known Baltic Bunodes, has been as fully described as the material permits. Its chief interest lies in emphasizing the presence of bunodomorph merostomes such as are associated with the eurypterids in the Baltic region, in our Bertie waterlime.

No new material has come to hand since the species was described.

Hemiaspis (?) eriensis Clarke

Hemiaspis (?) eriensis Clarke, N. Y. State Mus. Bul. 251, 1924, p. 119.

A very imperfect merostome from the Bertie waterlime at Buffalo has been recently figured as Hemiaspis (?) eriensis by Doctor Clarke (1924, p. 119). As this genus thus far was known only from the Silurian of Great Britain, the note was merely intended to point out the occurrence in America of this strange type of arachnoid.

Fig. 41.

Figure 41 Hemiaspis (?) eriensis Clarke. Original figure.

Pterygotus sp.

Plate 23, figure 7

The "Bullhead" rock of the Buffalo cement beds has afforded a ramus of a Pterygotus that, while poorly preserved, invites description because it is the first eurypterid from that much discussed stratum, and because it shows some features distinct from those of other species of Pterygotus.

The fragment is about 50 mm long and 5 mm wide, the main body nearly straight and but gently tapering towards the front. The

distal end is partly broken; it seems to have been as in P. buffaloensis. Only the teeth of the first order are observable and these stand partly straight upward (the two longest), and partly obliquely forward. This is a peculiar combination, the teeth in other species being usually so arranged that the free ramus has vertical, the fixed ramus slanting teeth (see Clarke and Ruedemann, pl. 77). It is therefore quite probable that the ramus as described represents a new form, as yet not sufficiently known to be determined. Both the ramus and the teeth are not compressed into a film as in the Bertie waterlime specimens, but preserved as well-rounded cavities that indicate a very solid massive structure of the original organ.

The occurrence of this fossil is further interesting as the first find of an eurypterid in the "Bullhead" bed. This bed has had a somewhat checkered career. Originally included with the Salina dolomite (later Bertie waterlime) which it overlies, it was separated from the Bertie waterlime by Grabau (1900 and 1901) and correlated with the Manlius limestone. Hartnagel (1903 and 1912) considered it as the western continuation of Hall's Coralline limestone (Cobleskill Hartnagel), and Schuchert (1903, p. 175) in the same year referred it to the Coralline limestone which he made the lower member of the Manlius formation. Grabau, (1909, p. 550) who later also considered it as faunally linked to the Cobleskill of eastern New York, has termed it Akron dolomite. As such it is now again held to be more closely connected with the Bertie waterlime, (Ulrich, 1911 chart, N. Y.; Williams, 1919, p. 87 ff.) and termed but an upper member of the Bertie (personal information by Professor Chadwick), to which it is bound by lithic gradation.

While the fauna of the Bertie waterlime consists mainly of eurypterids, the fossil here described is the first eurypterid recorded from the Akron dolomite. The specimen was associated in the same block with abundant individuals of Cyathophyllum hydraulicum Simpson, the most common and characteristic fossil of the bed.

Eurypterus lacustris Harlan

Eurypterus lacustris has been described by Clarke and Ruedemann (1912, p. 177) as occurring only in the Bertie waterlime. We have now before us three specimens: one the carapace, the other a portion of the abdomen and the third a segment, all of mature individuals of this species, from the Akron dolomite ("Bullhead") of the quarries of North Buffalo, N. Y. This occurrence, together with the finding of a chela of a fairly large Pterygotus (see above) leaves no doubt of the persistence of at least a part of the eurypterid fauna of the Bertie waterlime into Cobleskill time.

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Explanation of Plates

Plate 1

Dictyonema crassibasale Gurley

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Figure 1 Large specimen, natural size. Lockport limestone, Hamilton, Ontario.

Plate 1

E. Stein photo., R. R. del.

E. Stein photo., R. R. del.

Plate 2

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Portion of Gasport channel, showing contact with Lockport limestone above at top, and below at left.

C. A. Hartnagel photo., 1920.

Portion of Gasport channel, showing contact with Lockport limestone on top

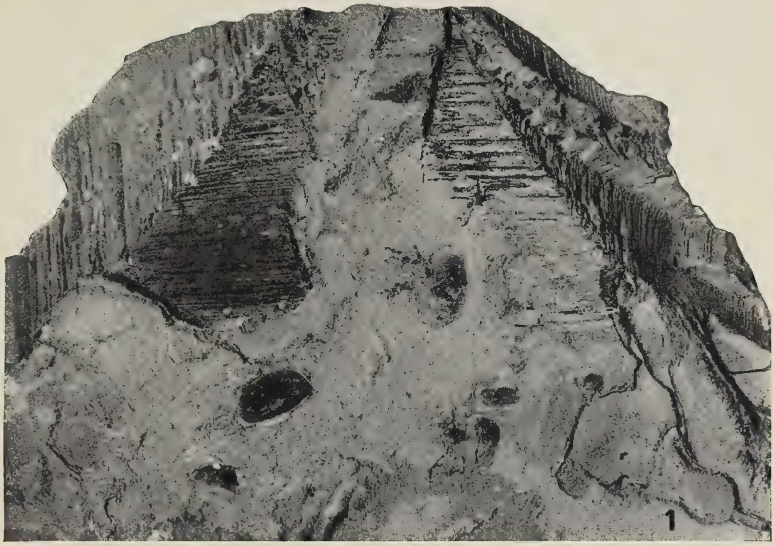
Plate 3

Figure 1 Dolomitic slab of Camillus shale, containing casts of salt crystals and specimens of Ctenodonta salinensis Rued.

Town of Lenox, Madison county, N. Y.

Figure 2 Casts of salt crystals in Bertie waterlime, North Buffalo, N. Y. Photographs about natural size.

Originals in New York State Museum.



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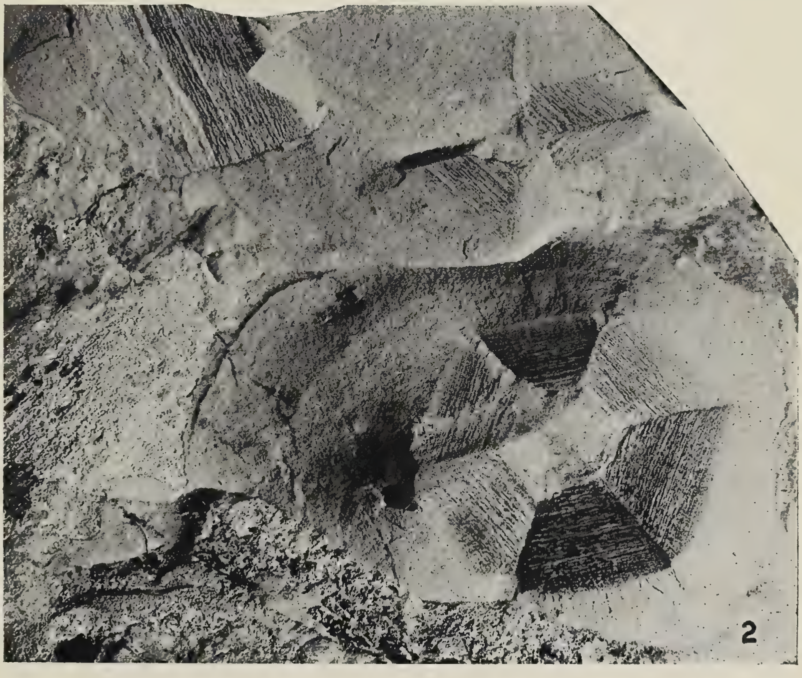

2

E. Stein photo.

Plate 4

Morania (?) **bertiensis** Ruedemann.

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Figure 1 Specimen (type). Bertie waterlime. North Buffalo, N. Y.

Sphenophycus (?) sp.

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Figure 2 Supposed flotation appendage of alga. Bertie waterlime. Litchfield, Herkimer county, N. Y.

Figure 3 Appendages of unknown origin, doubtfully referred to preceding fossil. Bertie waterlime. North Buffalo, N. Y.

Calithamnopsis silurica Ruedemann.

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Figure 4 Holotype. Bertie waterlime. North Buffalo, N. Y.

Chondrites verus Ruedemann.

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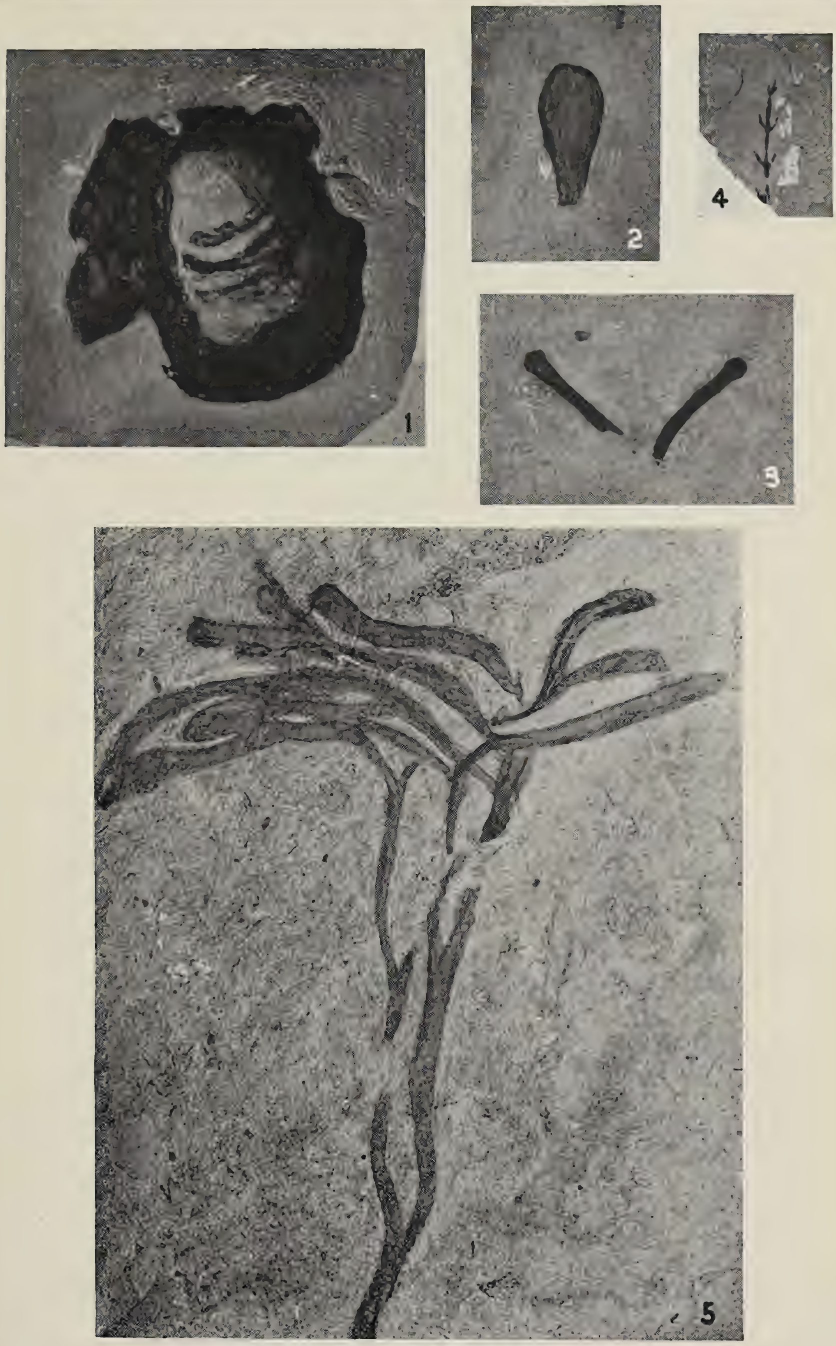
Figure 5 Holotype. Gasport lens of Lockport limestone. Gasport, N. Y. All figures are natural size. The originals are in the New York State Museum.



E. St. et E. P. photo., R. R. del.

Plate 5

Hostimella silurica Goldring.

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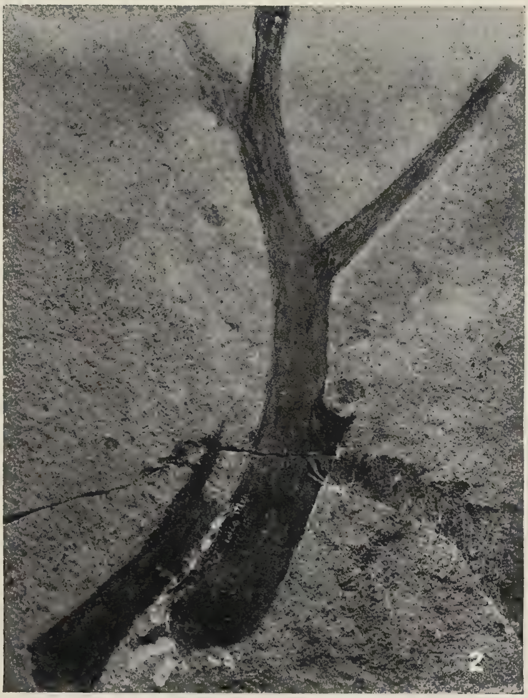
Figure 1 Specimen of irregular form. Cotype.

Figure 2 The type.

Bertie waterlime. North Buffalo, N. Y.

Figures are natural size. The originals are in the New York State Museum.



E. Stein photo.

Plate 6

Ascograptus similis Ruedemann

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Figure 1 Supposed basal disk. x 12.

Figure 2 Group of three distinct thecae. x 12.

Figure 3 Group of thecae with central body or section of axis. x 12.

Figure 4 Similar group with larger thecae. x 12.

Figure 5 Group showing connecting filament. x 12.

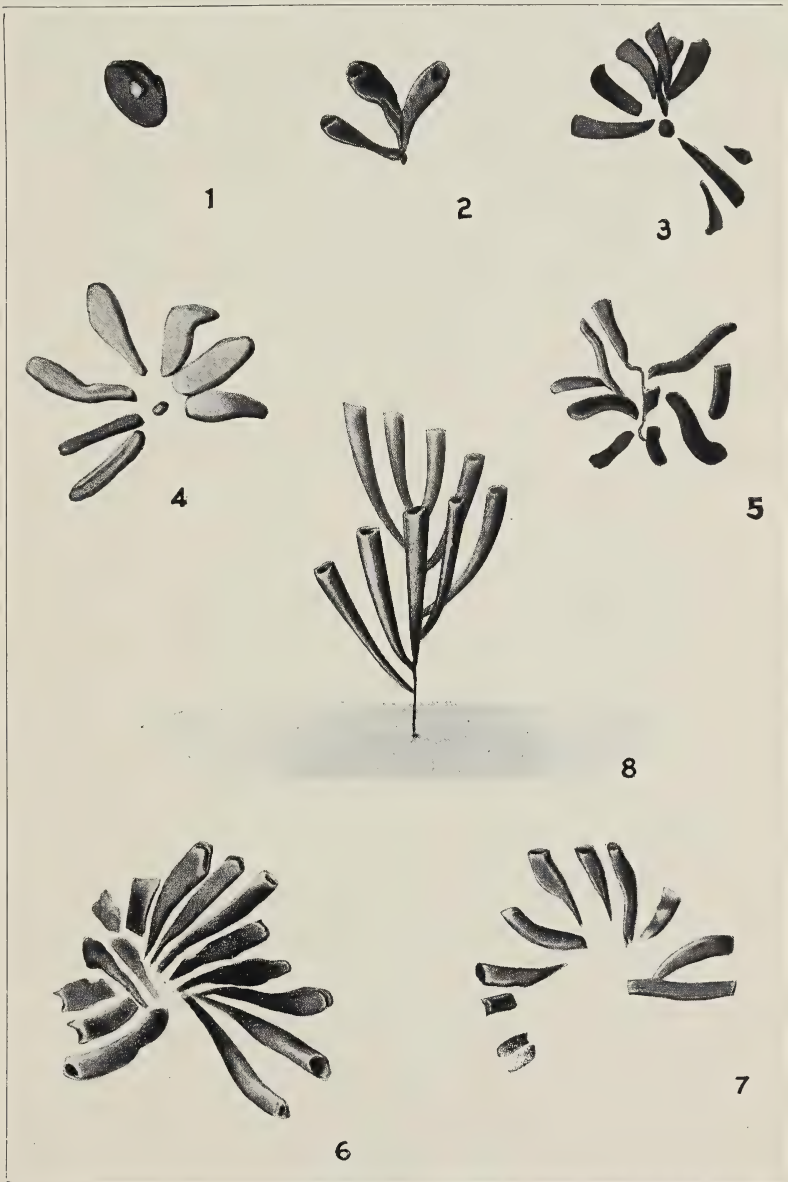
Figure 6 Most complete radiating group observed. The type. x 14.

Figure 7 Group, like preceding, suggestive of spiral arrangement of thecae. x 12.

Figure 8 Restoration of rhabdosome.

Gasport lens of Lockport limestone; Gasport, N. Y.

The originals are in the New York State Museum.



R. R. et E. K. B. del.

Plate 7

Diplospirograptus goldringae Ruedemann.

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Figure 1 Portion of colony retaining both the double spiral axes and the thecal tubes of one branch. Natural size. Type.

Figure 2 Usual appearance of the axes, as wavy branches, when stripped of the thecal tubes. Natural size. Cotype.

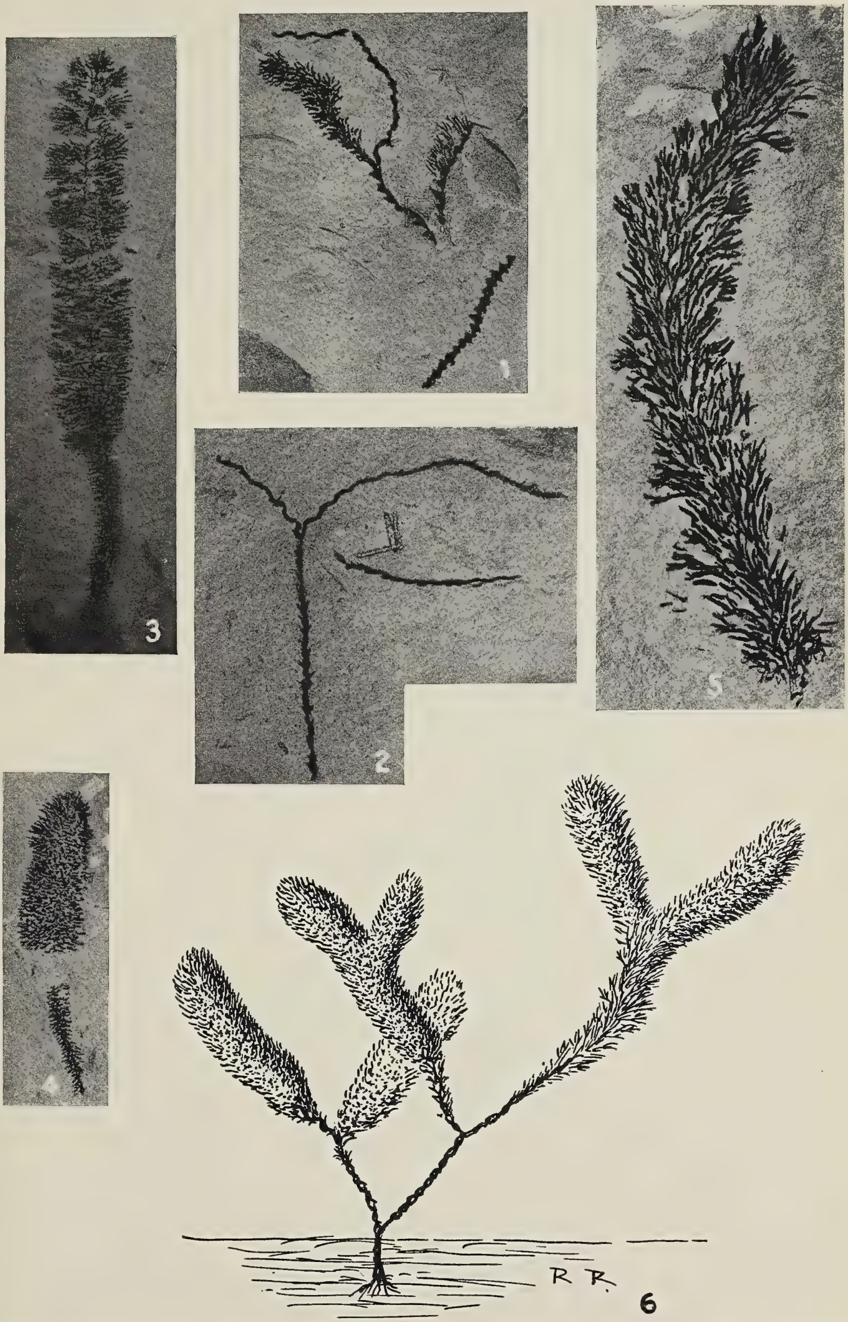
Figure 3 Large branch with distinct bundles of branching thecae. Natural size. Cotype.

Figure 4 Theciferous branch, showing the density of the distribution of the thecae.

Figure 5 Branch x 3, to show more distinctly the multifid character of the thecae. Cotype.

Figure 6 Restoration of appearance of whole colony. Natural size. Lockport limestone (Gasport lens), Gasport, N. Y.

All originals are in the New York State Museum.



E. S. et E. P. photo., R. R. del.

Plate 8

Medusaegraptus graminiformis (Pohlman)

(See plate 13, figure 1)

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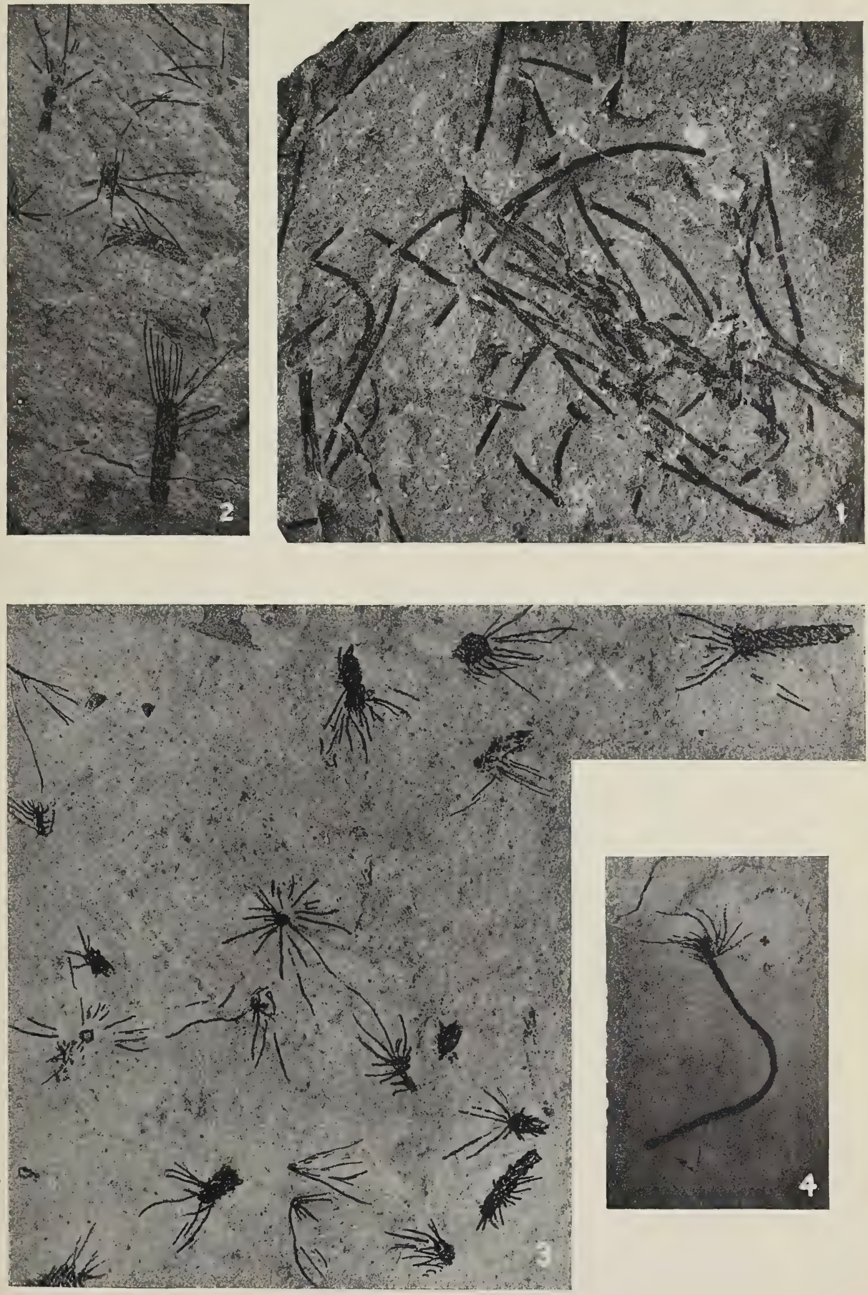
Figure 1 Portion of slab with "Chondrites graminiformis" Pohlman. Natural size.

Figures 2, 3 Portions of slabs with young rhabdosomes. x 3. In the center of figure 3 cross sections of the rhabdosomes are seen.

Figure 4 Part of mature specimen, showing the thecal tubes at distal end. Natural size.

Bertie waterlime, North Buffalo, N. Y.

The originals of the figures are in the New York State Museum, save that of figure 1, which is in the Museum of the Buffalo Society of Natural Sciences.



E. S. et E. P. photo., R. R. del.

Plate 9

Medusaegraptus mirabilis Ruedemann.

(See plates 10 and 11)

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Figures 1–3 Three growth stages of colonies.

Figures 4, 5 Two specimens showing the usual appearance of the fossil.

Figure 4 Type.

Figure 6 Specimen with traces of the larger distal thecal tubes. Cotype.

Lockport limestone (Gasport lens), at Gasport, N. Y.

All figures are natural size. The originals are in the New York State Museum.

E. S. et E. P. photo., R. R. del.

Plate 10

Medusaegraptus mirabilis Ruedemann

(See plates 9 and 11)

Page 32

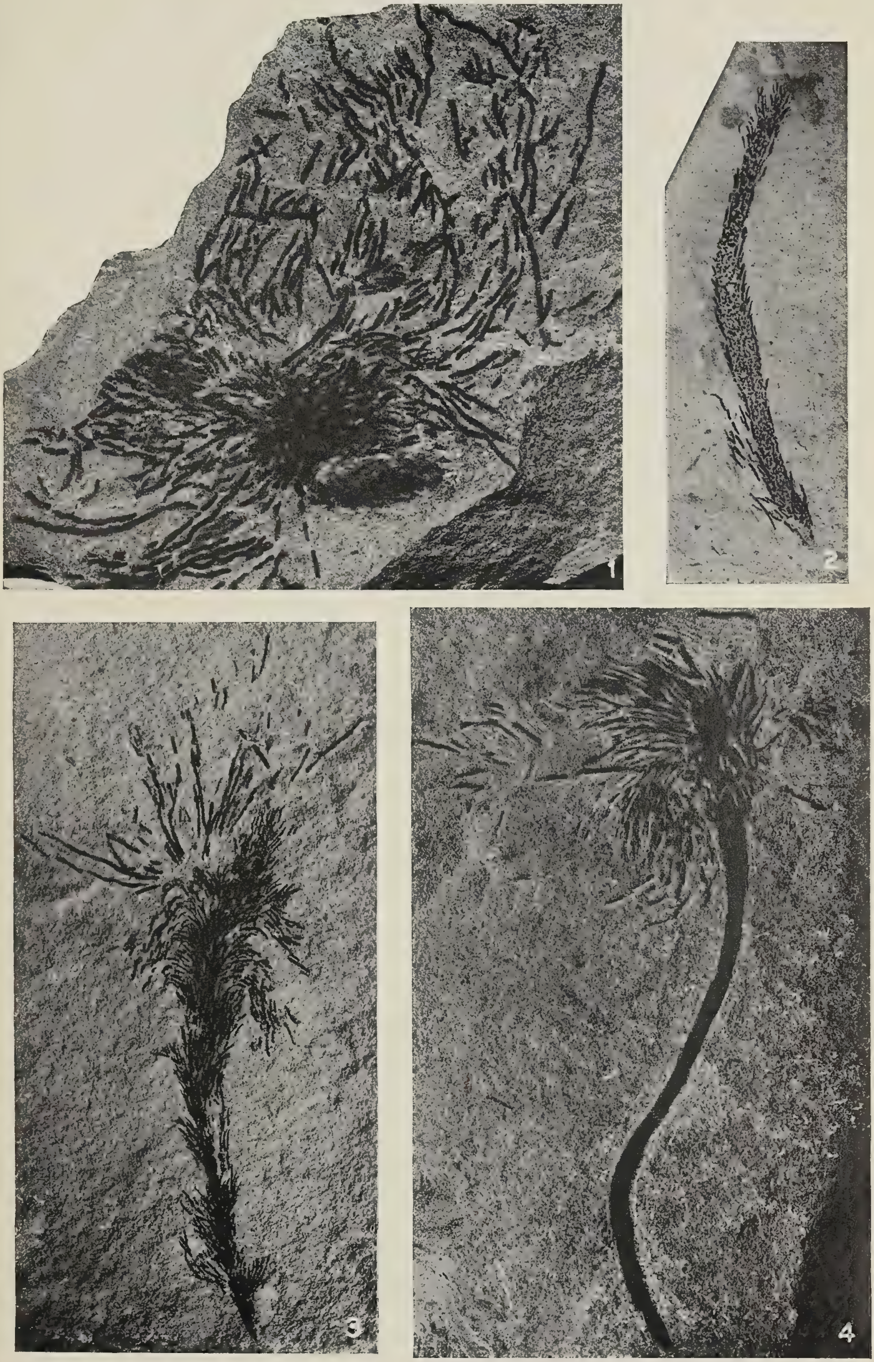
Figure 1 Distal portion of colony with radiating, flexuous, long thecal tubes, seen from above. Cotype.

Figure 2 Distal portion of stipe completely stripped of thecal tubes, showing the basal pores of the latter. Cotype.

Figure 3 Specimen retaining both the earlier thecal tubes along the stipe and the longer and thicker terminal ones. Cotype.

Figure 4 Specimen in which the stipe has become smooth and thickened save the distal portion, probably the last stage of the colony. Cotype.

Lockport limestone (Gasport lens), at Gasport, N. Y.



E. S. et E. P. photo., R. R. del.

Plate 11

Medusaegraptus mirabilis Ruedemann.

(See plates 9 and 10)

Page 32

Figure 1 Restoration of mature colony in natural size.

R. R.

Plate 12

Inocaulis lesquereuxi (Grote and Pitt)

Page 27

Figure 1 Detached branch showing club-shaped swelling of terminal portion. Natural size.

Figure 2 Large, perfectly preserved colonial stock. x $\frac{1}{2}$.

Bertie waterlime, North Buffalo, N. Y.

Climacograptus ultimus Ruedemann

Page 37

Figure 3 Group of stipes, associated with leg spine of eurypterid. Natural size.

Figure 4 Stipe x 3.

Bertie waterlime, North Buffalo, N. Y.

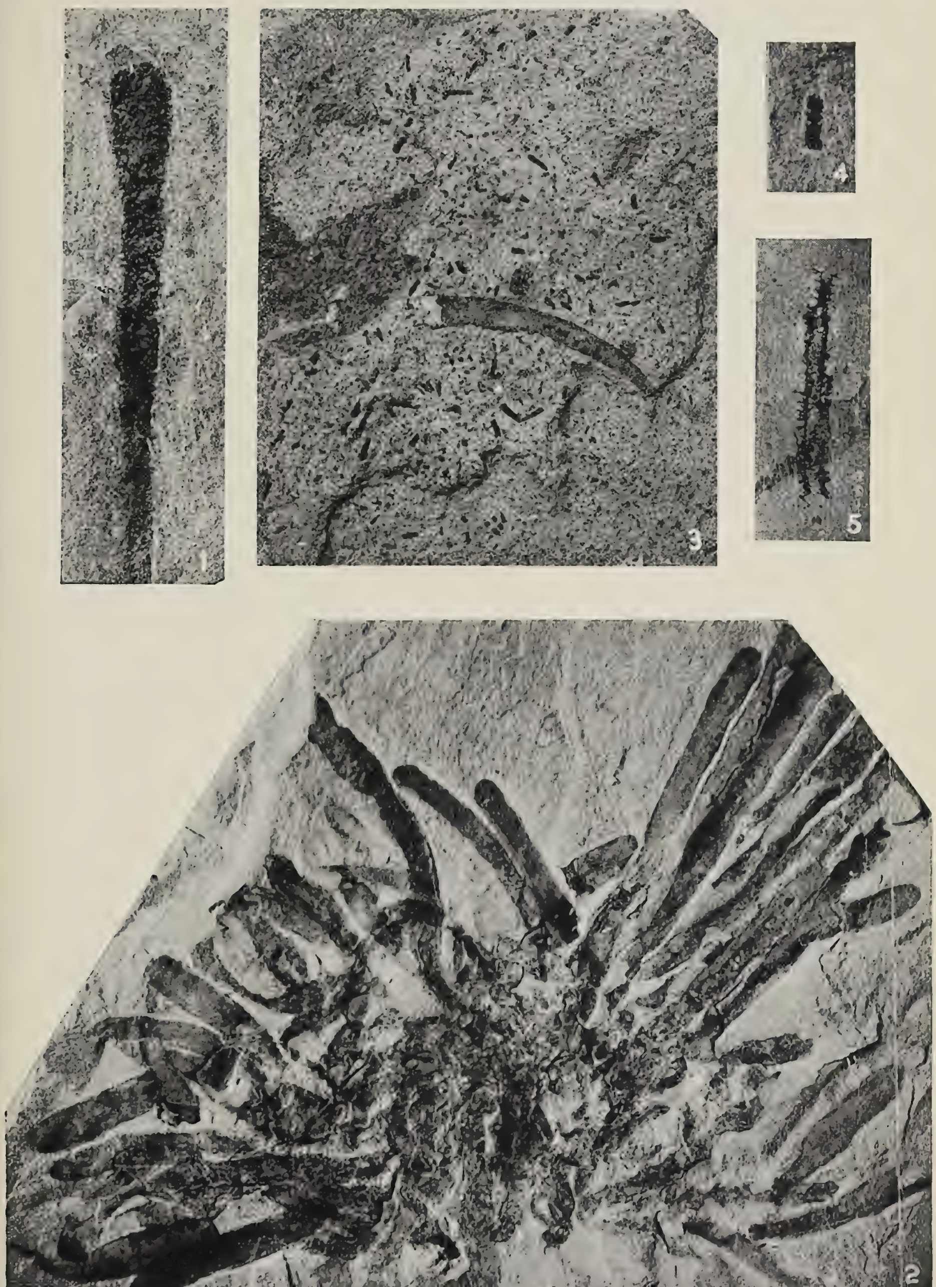
Orthograptus (?) sp.

Page 38

Figure 5 Single stipe observed. Natural size.

Bertie waterlime, North Buffalo, N. Y.

All originals are in the New York State Museum.



E. Stein photo., R. R. del.

Plate 13

Medusaegraptus graminiformis (Pohlman)

(See plate 8, figures 1–4)

Page 30

Figure 1 Restoration of complete colony. Natural size.

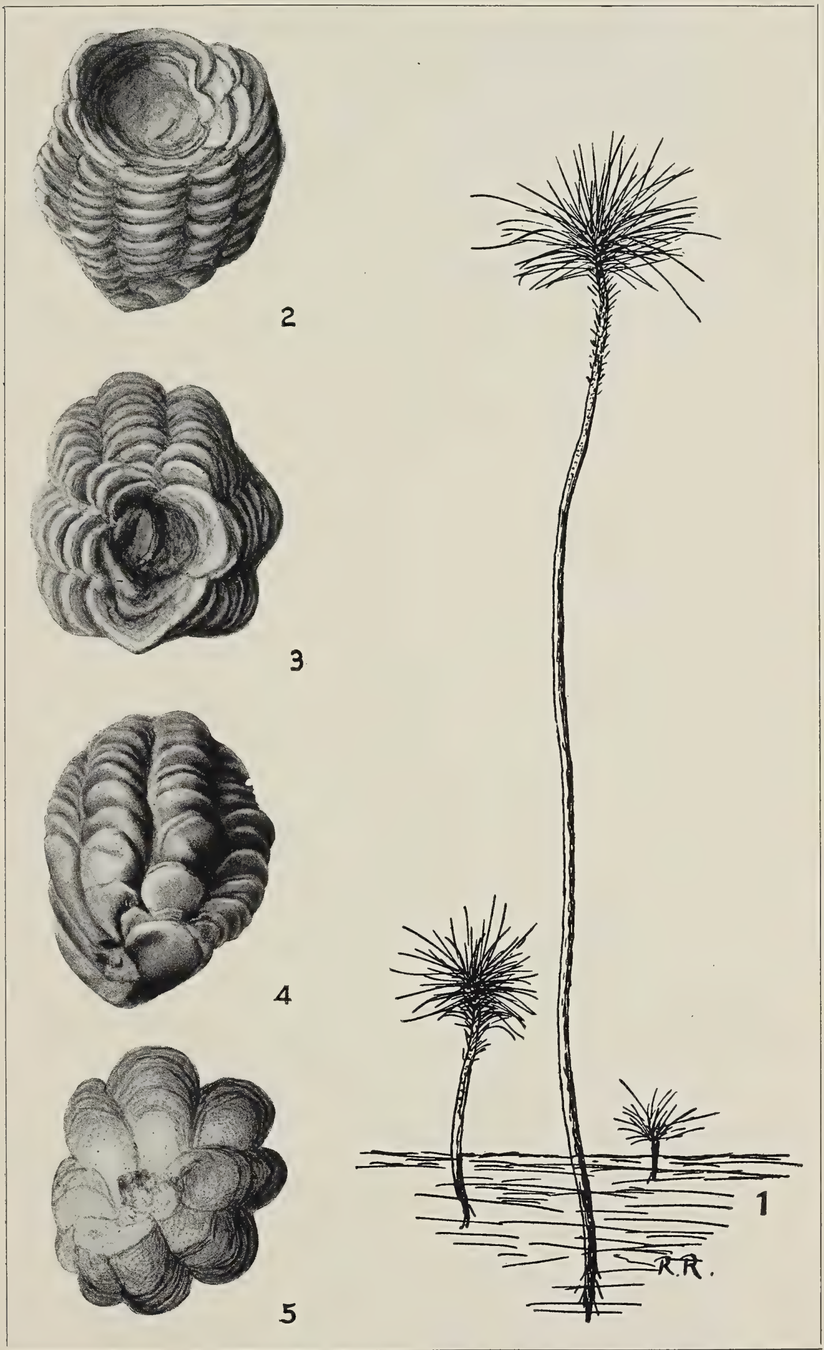
Pyrgocystis batheri Ruedemann

Page 39

Figures 2–5 Four views of type-specimen. Figure 2 View of short side. Figure 3 Top view. Figure 4 Long side. Figure 5 Base. x 6.

Bertie waterlime, North Buffalo, N. Y.

Original in New York State Museum.



R. R. et E. K. B. del.

Plate 14

Protoscolex batheri Ruedemann

Page 40

Figure 1 Well-preserved specimen with clitellum. Type.

Figure 2 Posterior fragment of specimen. Cotype.

Lockport limestone (Gasport lens), Gasport, N. Y.

Bertiella obesa Ruedemann

Page 43

Figure 3 Cotype, much contracted specimen.

Figure 4 Type; posterior extremity not fully preserved.

Bertie waterlime, North Buffalo, New York.

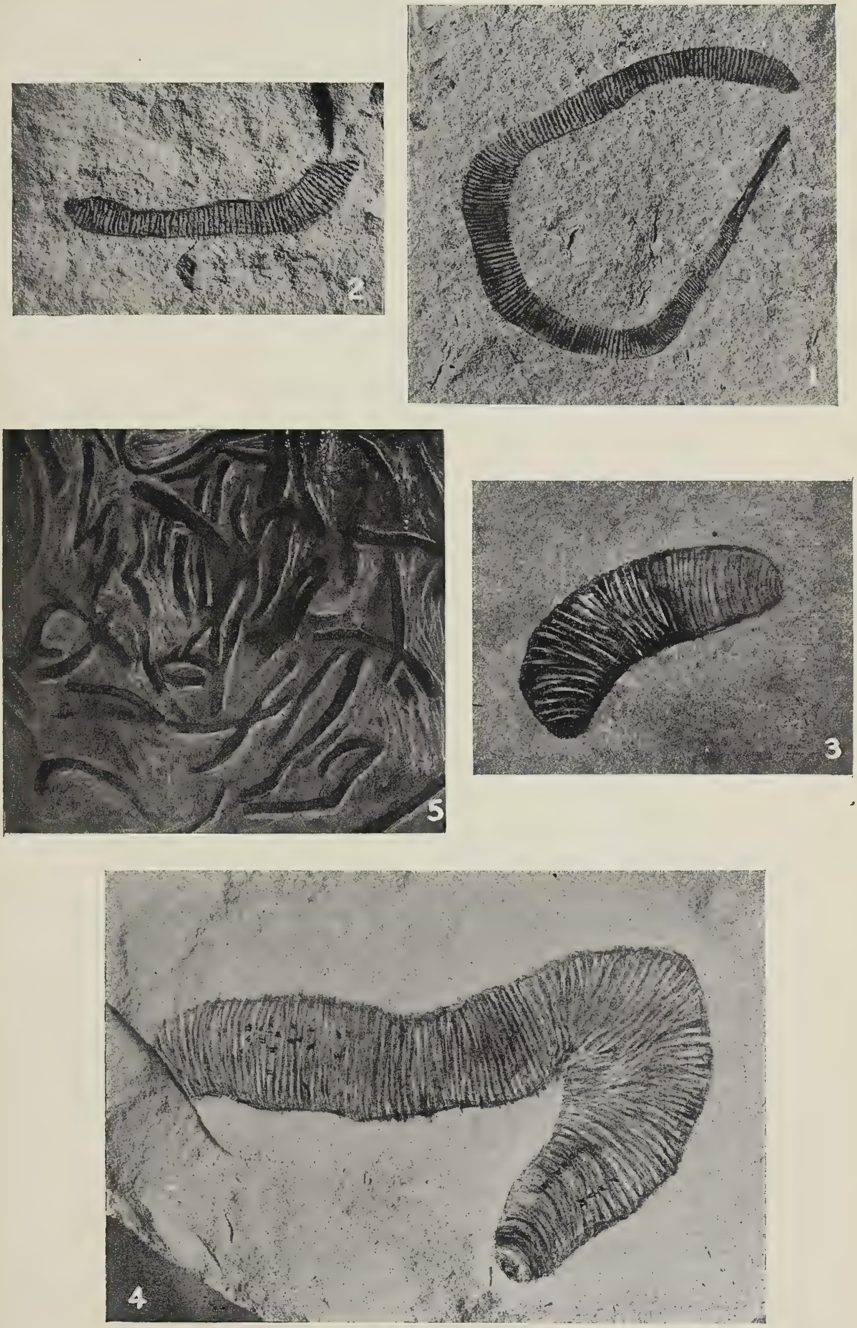
Excrementa

Page 45

Figure 5 Portion of slab covered with wormlike, structureless bodies, probably excrementa.

Bertie waterlime, North Buffalo, N. Y.

All figures are natural size. The originals of the figures are in the New York State Museum.



E. S. et E. P. photo., R. R. del.

Plate 15

Lingula lamellata Hall

Page 46

Figure 1 Valve retaining color-bands, x 3.

Lockport limestone (Gasport lens), Gasport, N. Y.

Trematis spinosa Ruedemann

Page 49

Figure 2 Brachial valve. Holotype x 3.

Lockport limestone (Gasport lens), Gasport, N. Y.

Spirifer (Delthyris) eriensis Grabau.

Page 50

Figures 3, 4 Two valves, x 2, from the Bertie waterlime, North Buffalo, N. Y.

Ceratopora (?) sp.

Page 38

Figure 5 Portion of colony, seen in natural section on weathered surface. Natural size.

Bertie waterlime, North Buffalo, N. Y.

Rhytimya buffaloensis Ruedemann.

Page 51

Figures 6, 7 Cotypes. x 2.

Bertie waterlime, North Buffalo, N. Y.

Hercynella buffaloensis O'Connell

Page 52

Figures 8, 9 Top and side views of complete specimen. Natural size.

Bertie waterlime, North Buffalo, N. Y.

Loxonema (?) **bertiense** Ruedemann.

Page 54

Figure 10 Holotype, natural size.

Bertie waterlime, North Buffalo, N. Y.

Serpulites corrugatus Ruedemann.

Page 70

Figure 11 Holotype x 3.

Rochester shale, Niagara river gorge.

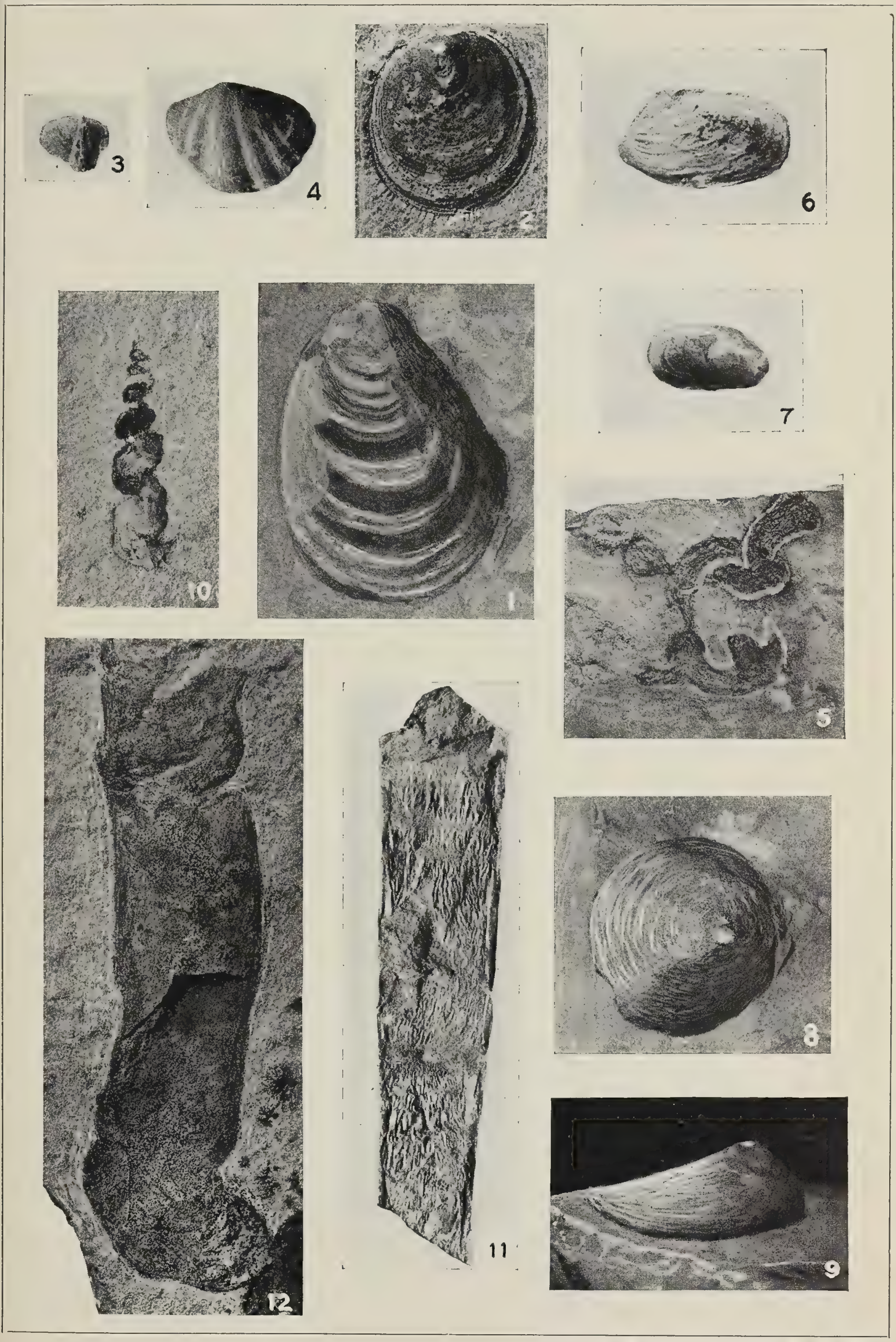
Dactylethra conspicua Ruedemann

Page 44

Figure 12 Type specimen. Natural size.

Lockport limestone (Gasport lens), Gasport, N. Y.

All originals are in the New York State Museum, save that of figure 10 which is in the Buffalo Museum.



E. S. et E. P. photo., R. R. del.

Plate 16

Figure 1 Portion of large rootlike plant remains (see p. 17) from the Bertie waterlime at Buffalo. x$\frac{1}{2}$.

Dawsonoceras oconnellae Ruedemann.

Page 56

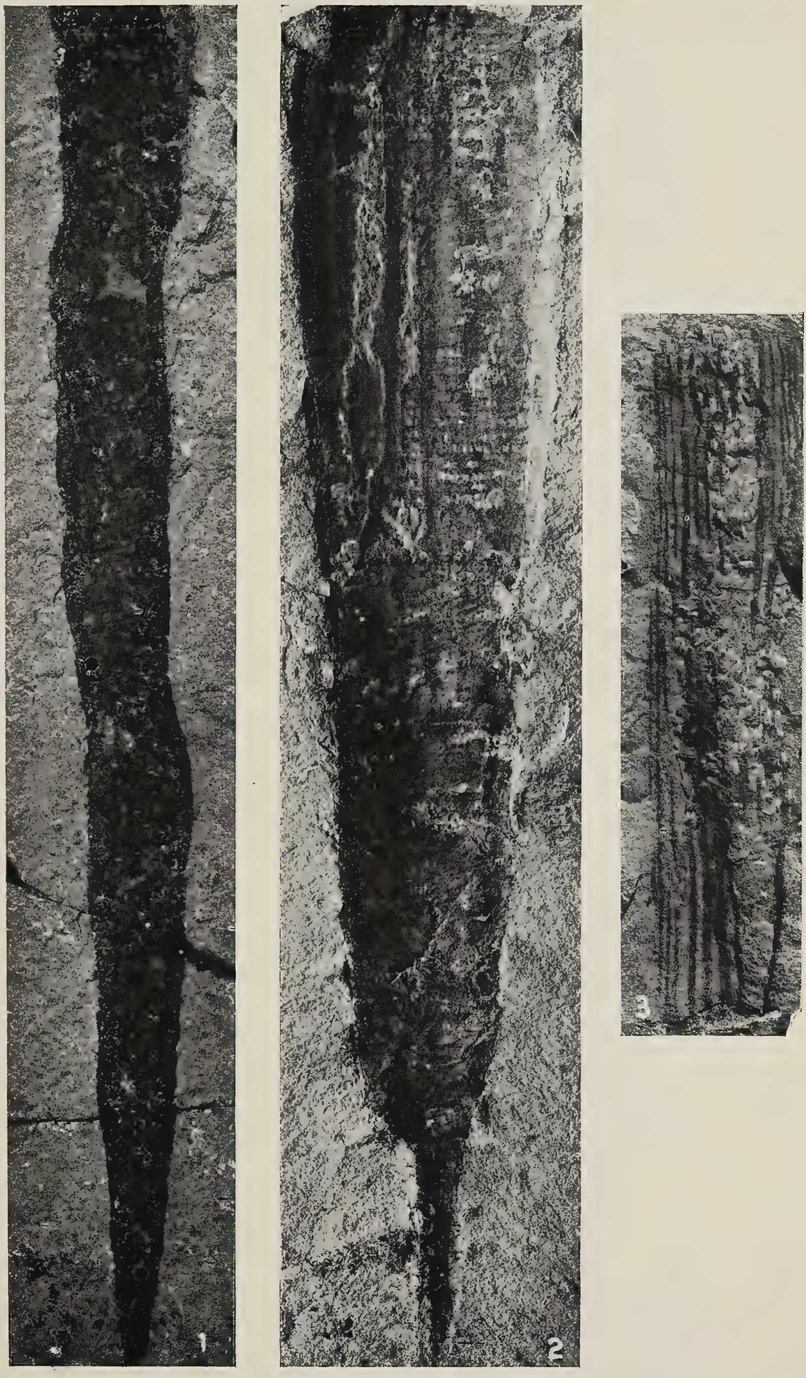
Figure 2 Holotype. x $\frac{2}{3}$. Bertie waterlime, North Buffalo, N. Y.

Orthoceras sp.

Page 55

Figure 3 Portion of specimen, showing color-bands. Natural size. Bertie waterlime, North Buffalo, N. Y.

The originals of figures 1 and 2 are in the Buffalo Museum, that of figure 3 is in the New York State Museum.



E. Stein photo.

Plate 17

Mitroceras gebhardi (Hall)

(See plate 19, figure 2)

Page 63

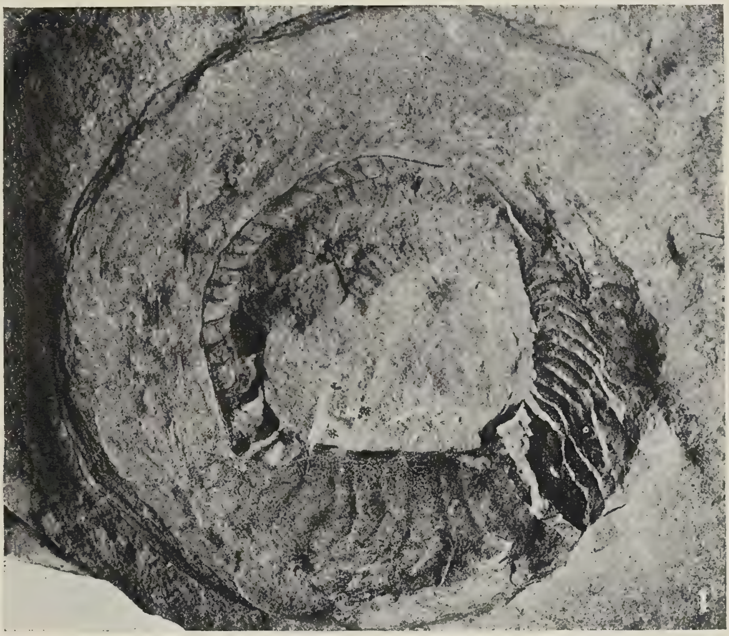
Figure 1 Compressed specimen from the Bertie waterlime at Buffalo, referred with doubt to this species (see p. 65).

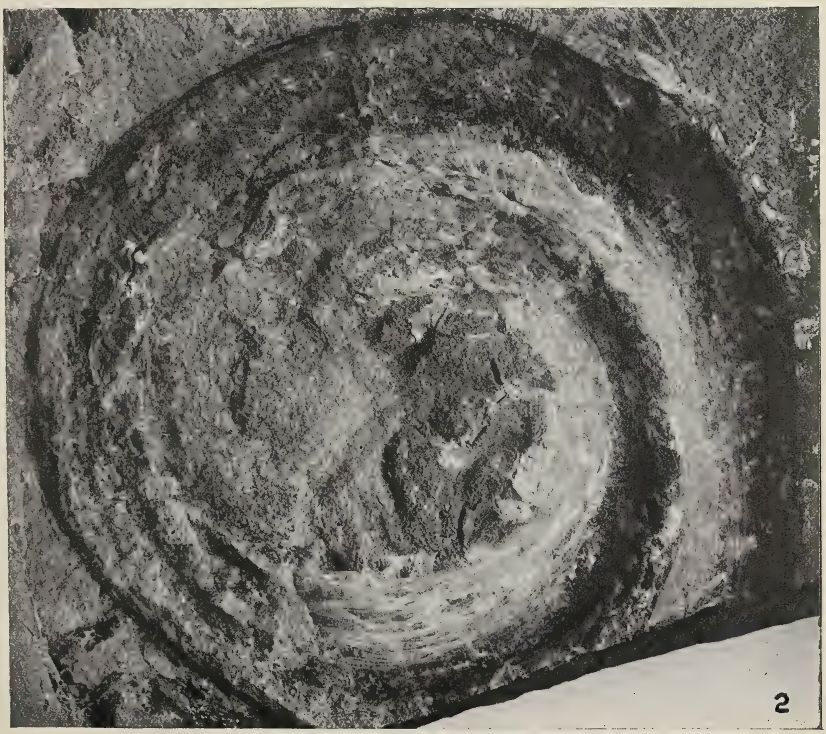
Trochoceras cf. **anderdonense** Grabau

Page 57

Figure 2 One of two specimens obtained in Bertie waterlime at Buffalo.

The reproductions are in natural size; the original of figure 1 is in the Buffalo Museum, that of figure 2 is in the New York State Museum.





E. Stein photo.

Plate 18

[119]

Pristeroceras timidum Ruedemann

Page 57

Figure 1 Top view of specimen showing the lobes or lateral sinuses of the brachial area and the teeth of the hyponomic slit.

Figure 2 Same, retaining the margin of hyponomic funnel.

Figure 3 Carbonaceous film, showing distinctly the outline of one-half of brachial area and of hyponomic slit of large specimen.

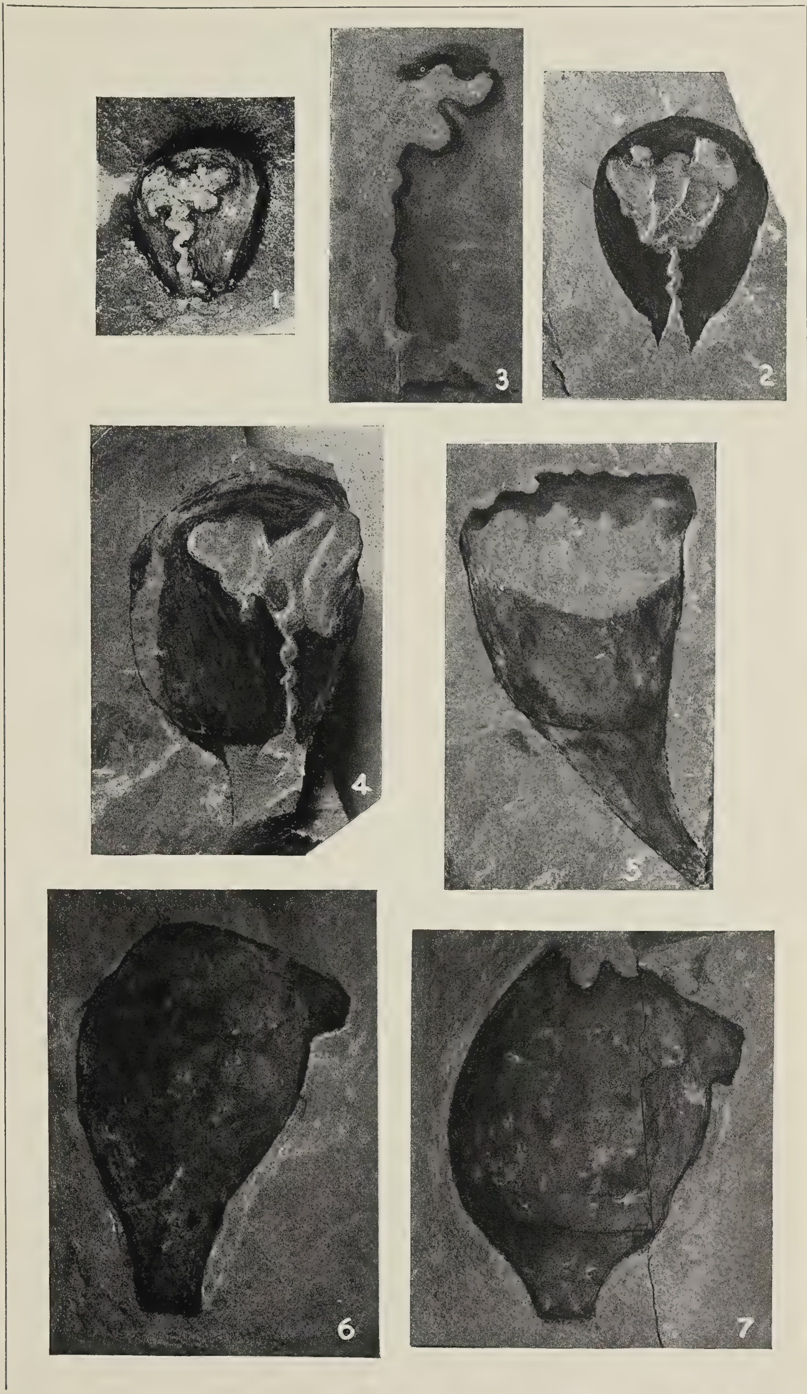
Figure 4 Living chamber obliquely compressed, showing distinctly alternating teeth of hyponomic slit.

Figure 5 Lateral view of conch with edge of aperture and hyponomic funnel (at right), showing relative size of living chamber.

Figure 6 Outline of specimen, completely flattened by lateral compression; and supposed to give a fairly accurate lateral view of conch, showing hyponomic funnel at right.

Figure 7 View of laterally compressed specimen, showing outline of living chamber and margin of aperture, with hyponomic funnel.

All figures are natural size. The originals of the figures are in the New York State Museum.



E. S. et E. P. photo., R. R. del.

Plate 19

Foersteoceras turbinatum (Hall)

(See plate 20, figure 1; plate 21, figures 1 and 2)

Page 65

Figure 1 Specimen showing siphuncle in upper volution. Natural size.

Cobleskill limestone. Schoharie, N. Y.

Mitroceras gebhardi (Hall)

(See plate 17, figure 1)

Page 63

Figure 2 Underside of holotype. Natural size.

Cobleskill limestone. Schoharie, N. Y.

The originals are in the New York State Museum.

1

2

E. Stein photo.

Plate 20

[123]

Foersteoceras turbinatum (Hall)

(See plate 19, figure 1; plate 21, figures 1 and 2)

Page 65

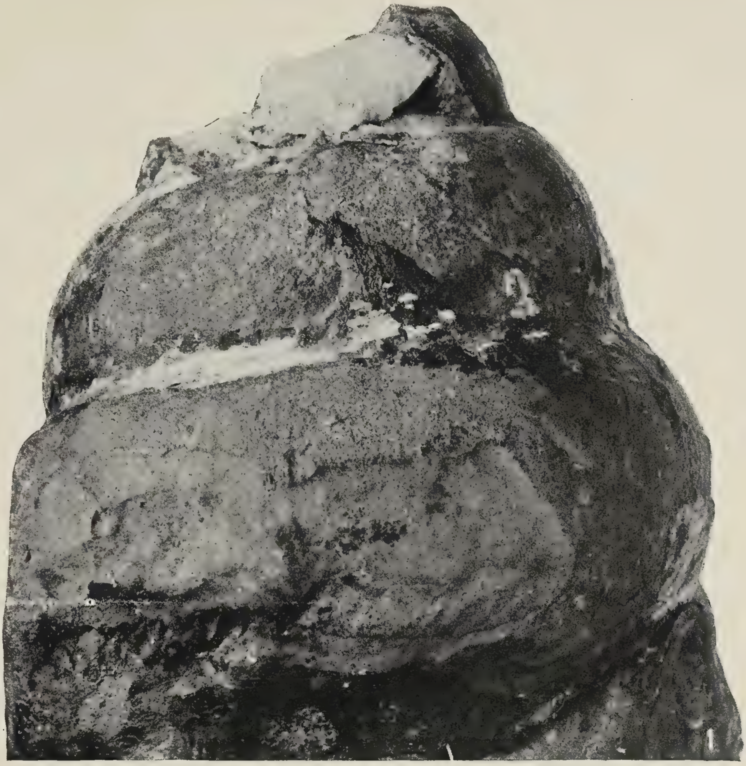
Figure 1 Upper portion of holotype, showing siphuncle at left of lower volution. Natural size.

Cobleskill limestone, Schoharie, N. Y.

Figure 2 Slab of Cobleskill limestone, showing its composition of coral stocks. x$\frac{1}{3}$.

Schoharie county, N. Y.

The originals are in the New York State Museum.



E. Stein photo.

Plate 21

Foersteoceras turbinatum (Hall)

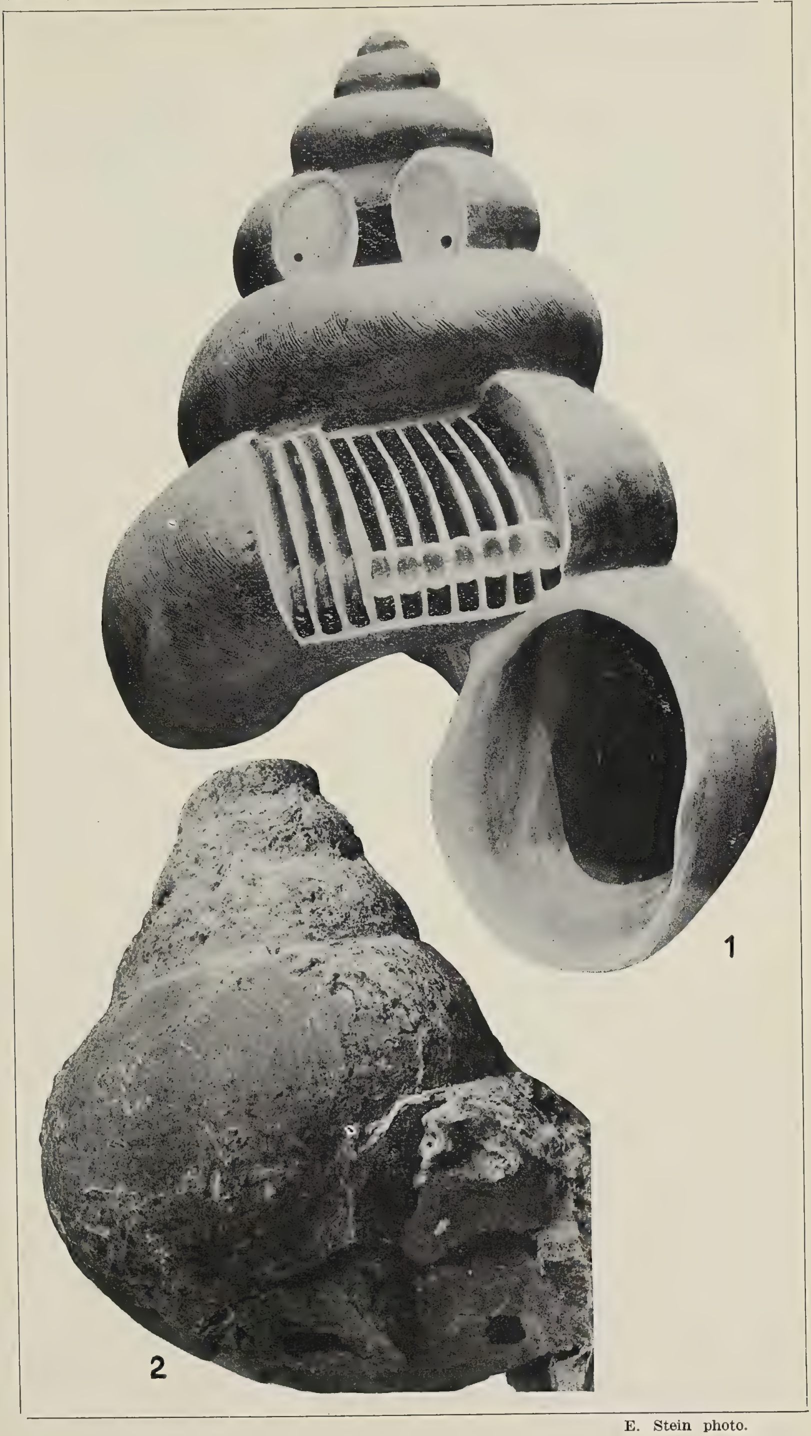
(See plate 19, figure 1; plate 20, figure 1)

Page 65

Figure 1 Photograph of a model made by the author.

Figure 2 A doubtful specimen from the Akron dolomite at Buffalo, referred to M i t r o c e r a s g e b h a r d i by A. W. Grabau (see p. 64).

The original of figure 1 is in the New York State Museum, that of figure 2 is in the Buffalo Museum.



E. Stein photo.

Plate 22

[127]

Conularia tenuicosta Ruedemann

Page 68

Figure 1 Well preserved specimen. Type x 2.

Figure 2 Enlargement, x 3 of portion of specimen to show fine costae.

Figure 3 Two specimens connected near apices. Natural size.

Lockport limestone (Gasport lens), Gasport, N. Y.

Conularia filicosta Ruedemann

Page 69

Figure 4 Holotype. x 2.

Rochester shale, Niagara river gorge.

Conularia perglabra Ruedemann

Page 69

Figure 5 Cotype. Natural size.

Figure 6 The type. Natural size.

Bertie waterlime. North Buffalo, N. Y.

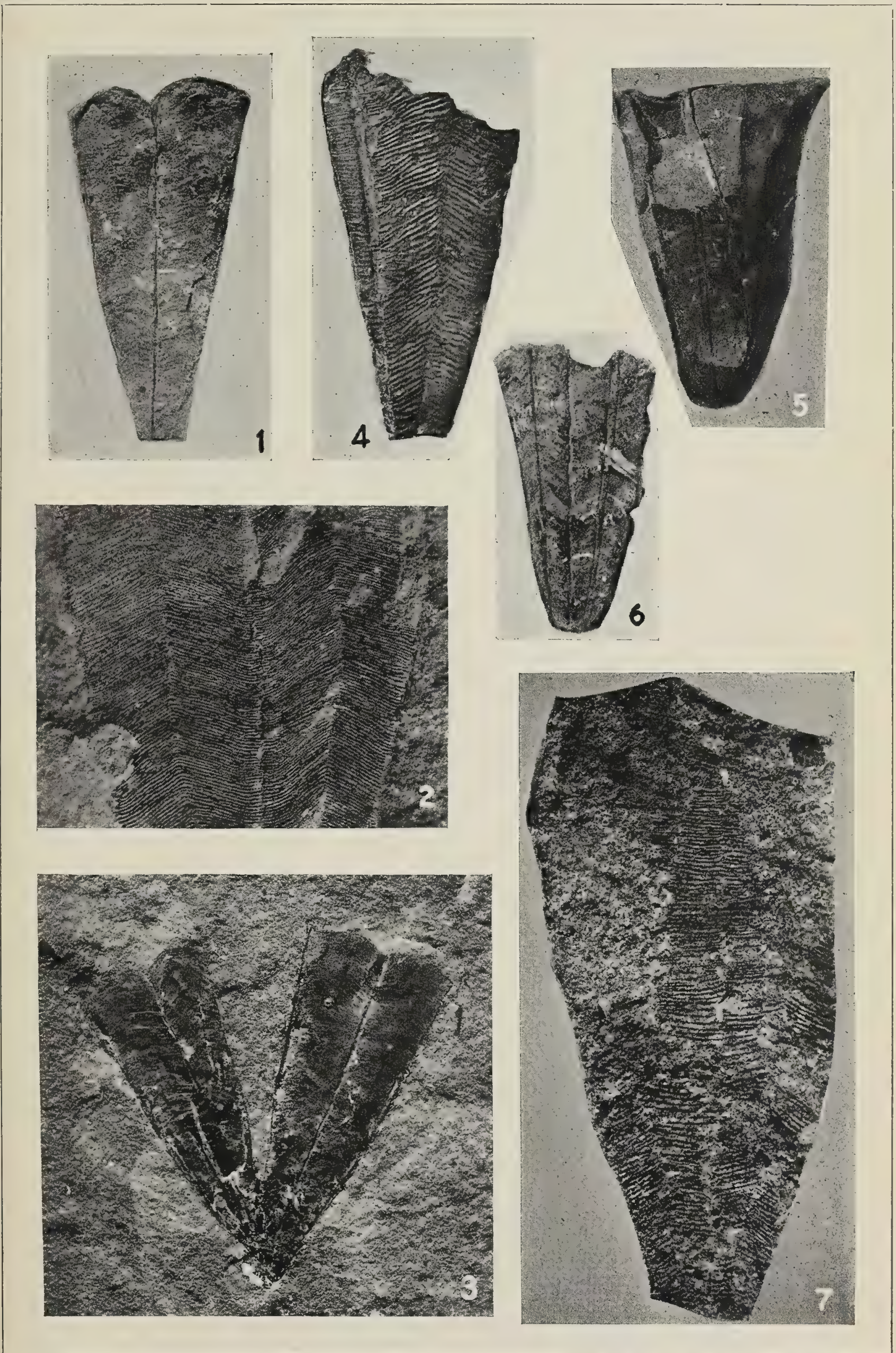
Conularia cataractensis Ruedemann

Page 67

Figure 7 Holotype. x 2.

Whirlpool sandstone member of Cataract formation, Niagara river gorge.

The originals of all figures are in the New York State Museum.



E. S. et E. P. photo., R. R. del.

Plate 23

Ceratiocaris acuminata Hall

Page 71

Figure 1 Telson of large individual.

Bertie waterlime. North Buffalo, N. Y.

Ceratiocaris clarkei Ruedemann

Page 73

Figure 2 Holotype. Drawn ventral side up.

Figure 3 " Mandible " (gastric teeth).

Figure 4 Cercopode.

All three specimens from the same small block of Bertie waterlime, found at Canandaigua, N. Y.

Lepidocoleus reinhardi Ruedemann

Page 76

Figure 5 Holotype.

Bertie waterlime. Williamsville near Buffalo, N. Y.

Anomalocaris (?) **kokomoensis** Ruedemann

Page 75

Figure 6 Holotype, x 9/10.

Kokomo waterlime, Kokomo, Ind.

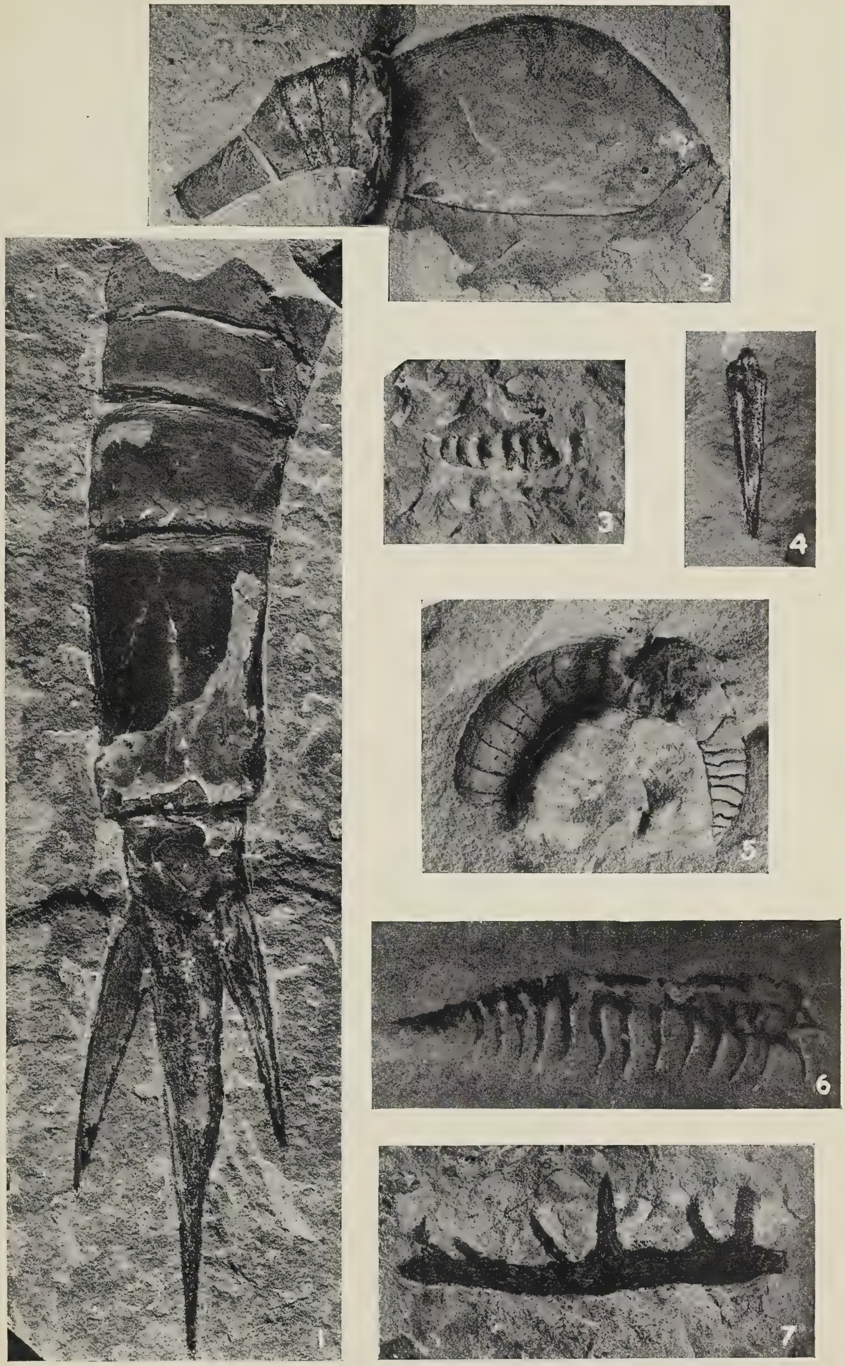
Pterygotus sp.

Page 79

Figure 7 Ramus of pincer.

Akron dolomite (" Bullhead "), North Buffalo, N. Y.

All figures except figure 6 are drawn natural size. The originals of all figures are in the New York State Museum.



E. S. et E. P. photo., R. R. del.

Plate 24

Bunaia woodwardi Clarke

Page 79

Figure 1 Dorsal side of cephalothorax. x 8.

Figure 2 Ventral side of cephalothorax. x 8.

Figure 3 Crushed and defaced head shield with a postabdomen of ridged segments. x 8.

Figures 1–3 Copies of original figures.

Bertie waterlime, North Buffalo, N. Y.

Emmelezoe minuta Ruedemann

Page 74

Figure 4 Holotype. x 7.

Bertie waterlime, North Buffalo, N. Y.

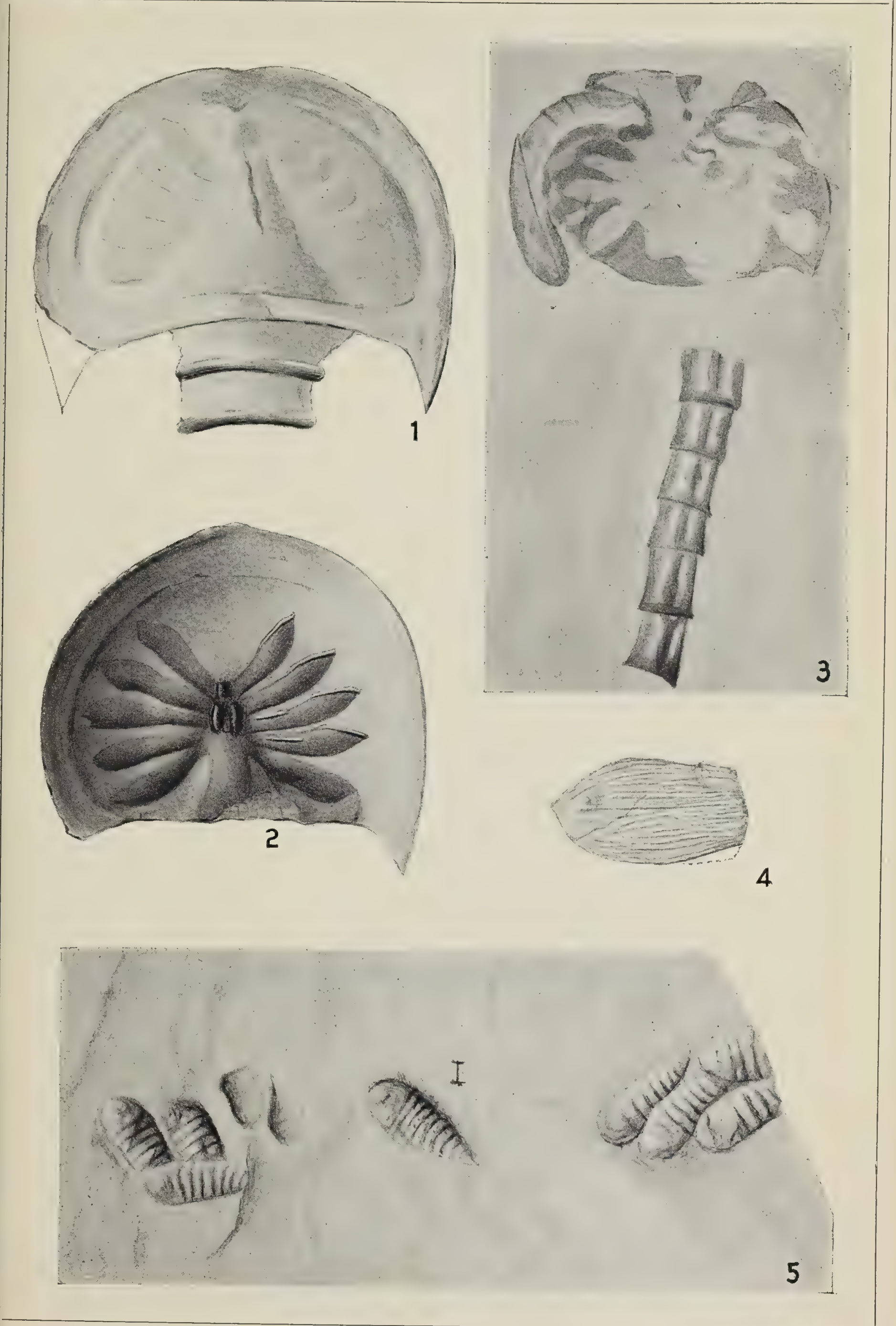
Eurypterus cf. **lacustris** Harlan

Page 80

Figure 5 Group of minute early growth stages of an eurypterid. x 7. See page 14.

Bertie waterlime, North Buffalo, N. Y.

The originals of the figures are in the New York State Museum, except that of figure 5, which is in the Buffalo Museum.



R. R. et G. S. B. del.

INDEX

New York State Museum Bulletin

Published by The University of the State of New York

No. 266 ALBANY, N. Y. June 1925

New York State Museum

John M. Clarke, Director

Homer D. House, *State Botanist*

REPORT OF THE STATE BOTANIST FOR 1924

ALBANY

THE UNIVERSITY OF THE STATE OF NEW YORK

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REPORT OF THE STATE BOTANIST FOR 1924

Scientific investigations. The investigative work of the State Botanist during 1924, and since the last published report of this office, has been directed chiefly toward the completion of the Annotated List of the Ferns and Flowering Plants of New York State, which was published as Museum Bulletin 254. This has involved much bibliographic work as well as study of the plants in the state herbarium. Collections and field studies have been carried on during the past year in the vicinity of Newcomb, Essex county; the east shore of Lake Ontario, in Jefferson and Oswego counties; and the vicinity of Oneida lake in the central part of the State. Collections of plants from these and other localities, which are of scientific interest have been incorporated into the herbarium. The ferns and flowering plants of peculiar interest are reported upon under Local Flora Notes, and the fungi under Notes on Fungi. A large number of fungi, both parasitic and saprophytic, chiefly of recent collection, have been studied in collaboration with Dr John Dearness, and reported upon under the heading New or Noteworthy Species of Fungi.

Doctor Peck's field notes. Investigators in mycology who have had occasion to refer to Doctor Peck's types or other collections of fungi in the state herbarium have often commented upon the fact that his published descriptions and reports of species already published do not give the year of collection. This is explained in large part by the fact that the species described or reported upon were collected during the year for which the publication is the annual report. Very rarely does he report upon any collection except of the current year, the various monographs, of course, excepted. These monographs were very largely, if not wholly, a compilation

of his formerly published and reported species without much reference to the considerable mass of undetermined material of those groups which was stored away in bundles. This is well illustrated by Kauffman's critical study of Doctor Peck's material of the genus Inocybe[1].

In his notebooks Doctor Peck described under tentative names a very large number of fungi which his critical judgment did not permit him to publish for one reason or another. Without doubt many of these are valid as well as unpublished species, as indicated by Murrill[2] in the case of Stropharia campestris Peck, and Stropharia rugoso-annulata Farlow; Peck. Since the notes were made almost without exception from fresh material they possess a considerable value to the later students of those groups represented. In addition, his notes upon many well-known as well as little known species, made from fresh material and never published, may undoubtedly be of assistance to other investigators.

In order that these voluminous notes, occupying some thirty large notebooks, might be available for reference, there has been prepared an index, which has been typed with two carbon copies. One of the copies has been placed in the office of pathological collections at Washington, and the other in the mycological laboratory of the New York Botanical Garden. From the original index Dr Howard A. Kelly of Baltimore, whose interest in mycological research is well known, has had six additional copies prepared which were distributed as follows: one to Harvard University, one to the Missouri Botanical Garden, one to the University of Michigan, one to Cornell University, one for his personal library, and one to Professor Beardslee.

Investigators working at Albany may have reference to these notes through the index. Those working at a distance and consulting the copies at the institutions mentioned, may secure upon application a transcript of such items as are desired. Unless the material to which the notes refer is quite ample, however, it is a rule of the New York State Museum not to lend material, especially type specimens.

Doctor Peck's notebooks covering a period from 1868 to 1913, have been numbered as follows:

---

[1] New York State Mus. Bul. 233–34: 43–60. 1921.
[2] Mycologia 14: 136, 139. 1922.

1 1868–71	18 1892–95
2 1869–70	19 1895–96
3 1870	20 1896
4 1871–73	21 1897–98
5 1873–74	22 1899–1900
6 1874–76	23 Copy of Massee's Monograph of Coprinus, and report of extra-limital species of fungi
7 1876–77	
8 1878	
9 1877–78	24 Extralimital new species, etc.
10 1879	25 Extralimital fungi
11 1879–80	26 1901
12 1881–83	27 1901–02
13 1884	28 1903–05
14 1885–86	29 1906–08
15 1886–87	30 1909–10
16 1888–89	31 1911–12
17 1890–92	32 1912–13

In addition to the above notebooks, there is a notebook containing 100 pages of descriptive matter and colored sketches of agrics, of his very earliest collection, apparently before he became State Botanist, mostly unnamed and impossible to index. Seven notebooks in addition to the above are devoted to Crataegus, two to contributions and one to identifications made for correspondents.

The typed index to the thirty-two notebooks enumerated above occupies 130 pages, and is subdivided into:

Personal mention
New York localities
Flowering plants and ferns
Mosses, liverworts, lichens and algae
Fungi

The last is naturally the important part of the index and occupies pages 25 to 130 of the manuscript.

Contributions to the state herbarium. The additions to the state herbarium since the last published report from this office in the form of contributions and exchanges are presented in the following list of contributors, which also indicates the number of specimens received from each:

Roy Latham, Orient	522
I. W. Clokey, Denver, Colo. (exchange)	254
E. Bartholomew, Stockton, Kan. (exchange)	210
Dr P. O. Schallert, Winston-Salem, N. C. (exchange)	116
J. B. Norton, Hartsville, S. C. (exchange)	152
British Museum, London, England (exchange)	100
Dr Harold St John, Pullman, Wash. (exchange)	100
Leland S. Slater, Coxsackie	60
Mr and Mrs E. A. Eames, Buffalo	56
C. A. Brown, Albany	50
Douglas M. White, Rochester	43
M. S. Baxter, Rochester	45
Dr J. J. Davis, Madison, Wis	53

F. A. Ward, Cortland	35
E. P. Killip, Washington, D. C	30
Miss E. M. Slater, El Paso, Texas	27
Dr G. R. Bisky, Winnipeg, Canada	21
U. S. Dep't of Agriculture, Washington, D. C	15
William C. Ferguson, Hempstead	15
Miss C. C. Haynes, Highlands, N. J	13
W. C. Muenscher, Ithaca	11
S. H. Burnham, Ithaca	9
Rev. H. M. Denslow, New York	7
Rev. G. H. French, Albany	5
Dr C. E. Fairman, Lyndonville	5
Dr John Dearness, London, Ont., Canada	5
Miss Helen LaForce, Ballston Lake	4
Mrs C. E. Christian, Canandaigua	3
F. H. Benedict, Watermill, Long Island	3
Annabel Martin, Broadalbin	3
Dr W. H. Beauchamp, Syracuse	2
George E. Andrus, Middletown	2
Mrs O. P. Phelps, Saratoga Springs	2
One each from: Charles Gilbert, Honeoye; Dr William Mansfield, Albany; Frank Dobbin, Shushan; W. T. Shoemaker, Elmira; Dr W. J. Nellis, Albany; Mrs L. F. Jolley, Berkshire, Vt.; Dr J. R. Weir, Washington, D. C.; Neil Hotchkiss, Syracuse; E. J. Stein, Albany; Mrs Charles Beach, Beachview; C. T. Walton, Port Henry; Dr M. D. Leonard, Albany; Mrs H. H. Fairbanks, Bainbridge; F. W. Pugsley, Pittsford; P. D. Phair, Presque Isle, Me.; R. G. Pierce, Washington, D. C.; Dr D. R. Sumstine, Pittsburg, Pa; Miss S. M. Williamson, St Petersburg, Fla.; W. T. Jervis, New York; F. C. Stewart, Geneva; and Dr J. B. Todd, Syracuse	21
Total	1 999

Of these specimens, 853 were received during the season of 1924; 413 during the season of 1923, and 733 during the season of 1922.

Additions to the herbarium. The total number of specimens which have been added to the collections from all sources during the year 1924 is 1355, of which 510 were received by contribution or exchange, and 845 by collections made by the State Botanist. During 1923 the number of specimens added to the collections was 1108, and during 1922 the number was 1243. These figures do not include a large number of specimens collected by the Botanist for purposes of scientific exchange, nor do they include such specimens received as contributions or in exchange which have not, for one reason or another, been mounted or prepared for the herbarium. In connection with the curatorial work made in connection with the collections, the services of recent temporary assistants, Helen LaForce and C. A. Brown, have been most satisfactory and indispensable. The bulk of routine and curatorial work in the State Botanist's office is so great that permanent assistance is needed in order to carry forward any extensive work in botanical research.

The collections by the State Botanist, noted above, were made in the following counties of the State:

Albany	Madison	Warren
Bronx	Nassau	Ulster
Essex	Oneida	Saratoga
Fulton	Onondaga	Schenectady
Greene	Oswego	Montgomery
Hamilton	Rensselaer	Herkimer
Jefferson	Rockland	
Lewis	Suffolk	

Identifications. The State Botanist's office has been called upon to identify 425 specimens of plants including many edible and poisonous mushrooms during 1924. These identifications were requested by 130 persons, mostly by mail, some of them, however, by personal visit to the office. The demand for this service varies considerably from year to year. During 1923 the determinations numbered 450 for 132 persons, while during 1922 the determinations numbered 753 for 194 persons.

Visitors. The extensive collection of the state herbarium, including as it does a very large number of type specimens of fungi, is frequently consulted by specialists in various lines of research. Such facilities as the herbarium room affords is always placed at their disposal and personal attention is given to facilitate their work.

Lectures. During 1924 the State Botanist has delivered eight lectures before various organizations upon the subject of plant life, wild flowers and wild flowers needing protection.

Myxomycetes of the Cayuga lake basin. By purchase a set of Myxomycetes collected in the Cayuga lake basin by F. B. Wann and W. C. Muenscher has been secured for the herbarium. The collectors have already published an account of their collections (Mycologia 14:38–41. 1922), so that the list of species represented, fifty in number, need not be repeated here.

Plants from Bonaventure, Quebec. During the latter part of July 1923, Mr and Mrs Edward A. Eames of Buffalo collected a number of plants on this portion of the Gaspe peninsula which were later contributed to the State Museum. Among the localities represented are Bic, St Anne des Montes, Port Daniel, Perce and Bonaventure island. Following is a list of the species received:

Antennaria dioica Greene
Anticlea elegans (Pursh) Rydb.
Asplenium viride Huds.
Cakile edentula Bigel.
Carex angustior Mackenzie
Carex atratiformis Britton

Carex Crawfordii Fernald
Carex disperma Dewey
Carex stipata Muhl.
Campanula rotundifolia L.
Cerastium arvense L.
Dryopteris Filix-mas (L.) Schott
Elymus arenarius L.
Erigeron hyssopifolium Michx.
Eriophorum Chamissonis C. A. Mey.
Eriophorum viridicarinatum (Engelm.) Fernald
Glaux maritima L.
Halenia deflexa (J. E. Sm.) Griseb.
Juncus alpinus Vill.
Juncus bufonius L.
Lepargyraea canadensis (L.) Greene
Lepidium campestre L.
Lepidium sativum L.
Malaxis monophylla (L.) Sw.
Pinguicula vulgaris L.
Polygonum viviparum L.
Polystichum Lonchitis (L.) Roth
Potentilla pectinata Raf.
Saxifraga Aizoon Jacq.
Scirpus microcarpus Presl.
Spergula arvensis L.
Saxifraga aizoides L.
Ranunculus Cymbalaria var. alpinus Hook.
Triglochin palustris L.
Triglochin maritima L.
Trisetum spicatum (L.) Richter

LOCAL FLORA NOTES IX

Since the publication of Local Flora Notes VIII,[1] there has been published by the writer an Annotated List of the Ferns and Flowering Plants of New York State.[2] With this as a basis it will be the purpose of this and future Local Flora Notes to make additions to the known species and varieties of plants of the State, to make certain corrections and other additions as might seem to come within the scope of this title.

Albany county

A series of articles in the Albany Zodiac in 1835 and 1836 by Dr James Eights brings to mind most forcibly the great changes which have taken place in the flora of the sand plains between Albany and Schenectady and especially the disappearance of many attractive wild flowers and ferns, which to judge from his remarks were then quite common. He speaks of finding in blossom such plants as:

Linnaea borealis (probably long since disappeared from the woods of these sand plains. Doctor Peck seems not to have found it there in his day).

Plantanthera orbiculata (Lysias orbiculata (Pursh) Rydb.)

Plantanthera dilatata (Limnorchis dilatata (Pursh) Rydb.)

Habenaria fimbriata (probably our Blephariglottis psycodes (L.) Rydb., now exceedingly rare here).

Habenaria ciliaris (Blephariglottis ciliaris (L.) Rydb., known to Beck, Pearson and others, and was last collected here by Doctor Peck about 1908, since which time no trace of it has been found.)

Pterospora andromeda (Eights gives to this plant the common name of Albany beechdrops, because, as he states, it was first found near Albany by Dr Edwin James. There are no recent records for it in this vicinity.)

Cassia marilandica L.

Hypericum ascyroides (now called H. Ascyron L., and not recently collected here).

Pedicularis pallida Pursh (now called P. lanceolata Michx., and unknown in the sand plains, still persisting in a small patch north of Rensselaer).

Eights also lists as common flowering plants of the sand plains Lobelia cardinalis, Parnassia caroliniana,

[1] New York State Mus. Bul. 243–44: 13–58. 1923.
[2] New York State Mus. Bul. 254. 1924.

Schwalbea americana, Gerardia glauca of Eddy, Gentiana crinita, and Viola pedata. Of these only Viola pedata and Gentiana crinita are still found. Doctor Eights speaks of the abundance of the Trailing Arbutus, Epigaea repens L., but at the present time there are but a few scanty and widely separated patches of it left.

Ranunculus flabellaris Raf.

In a small pond near Wemple, *H. D. House 10004*, May 22, 1924.

Amelanchier amabilis Wiegand

Dry woods near Lawson's lake, Helderberg mountains, *H. D. House 10006,* June 1, 1924.

Carex aurea Nutt.

Wet soil near Guilderland Center, *H. D. House 10436,* August 3, 1924.

Rosa Lyoni Pursh

Dry thickets, Voorheesville, *House 10607,* August 28, 1924. Glenmont, *House 6573,* 1919. The specimens from which was made the colored illustration of Rosa virginiana, in the Wild Flowers of New York, has been determined by both Doctor Rydberg and Mrs Erlanson as Rosa Lyoni.

Rosa obovata Raf.

Thickets, Guilderland Center, *House 10788,* October 2, 1924.

Rosa subblanda Rydberg

Thompson's lake, *Peck.* Also collected at Cooperstown Junction and at Elizabethtown by *Peck.*

Rosa serrulata Raf.

Dry, sandy woods near Karner, *H. D. House 6367,* June 26, 1919. Glenmont, *House 10342,* July 15, 1924.

Thalictrum dasycarpum Fisch. & Mey.

Dry woods, Green Island, *H. D. House 10373,* July 22, 1924.

Fraxinus Michauxii Britton

River banks, Green Island, *H. D. House 10368,* July 22, 1924; Guilderland Center, *No. 10628,* September 7, 1924.

Doellingeria infirma (Mich.) Greene

Dry woods, Green Island, *H. D. House 10365,* July 22, 1924.

Azalea viscosa L.

Marsh near Voorheesville, *H. D. House 10608,* August 28, 1924. The chief vegetation in this marsh consists of great thickets of blueberry bushes, three distinct forms being easily recognizable; Vaccinium corymbosum, V. corymbosum var. pallidum, and V. atrococcum. Among other species worthy of note here are Anchistea virginica (L.) Presl., Vaccinium Oxycoccus L., Rynchospora alba, Larix laricina and Eriophorum virginicum.

Heliopsis scabra Dunal.

Shore of Watervliet reservoir, Guilderland Center, *H. D. House 10603.* Here also was found on August 28, 1924, Polygonum Muhlenbergii S. Wats., and Eragrostis hypnoides (Lam.) B. S. P.

Solidago ulmifolia Muhl.

Thickets near Glenmont, *H. D. House 10647,* September 11, 1924.

Cortland county

Corylus cornuta Marsh.

Dean's pond near Marathon, *F. A. Ward,* July 26, 1924. Here also grows Pontederia cordata L., both being rather rare in this region. Mr Ward also sends the following plants in addition to the above two mentioned:

Panicularia grandis (S. Wats.) Nash, near Cortland
Scirpus atrovirens Muhl., near Cortland
Veronica scutellata Schw., near Cortland
Calamagrostis canadensis L., near Preble
Agropyron repens (L.) Beauv., near Preble
Bromus tectorum L., near Preble
Blephariglottis psycodes (L.) Rydb., near Preble
Linum usitatissimum L., near Preble
Linaria minus (L.) Desf., near Preble
Campanula aparinoides Pursh, near Preble
Andromeda glaucophylla Link, near Little York
Potentilla fruticosa L., near Little York
Cathea tuberosa (L.) House, near Little York
Vaccinium Oxycoccus L., near Little York
Pogonia ophioglossoides (L.) Ker., near Little York

Dutchess county

Ajuga repens L.

Millbrook, *Helen M. Fort,* June 2, 1924.

Essex county

The following list of lichens represent the recent collections in the vicinity of Newcomb, and the determinations of them by G. K. Merrill:

Tryletelium virens Tuckerm.
Conotrema urceolatum (Ach.) Tuckerm.
Graphis scripta (L.) Ach.
Baeomyces roseus Pers.
Cladonia cristatella Tuckerm.
    incrassata Merrill
  deformis extensa (Hoffm.) Wain.
  fimbriata simplex (Weis.) Flk.
  gracilis dilatata (Hoffm.) Wain.
  multiformia Merrill
  ochrochlora ceratodes Flk.
  pyxidata (L.) Hoffm.
    choraphana (Spreng.) Flk.
    neglecta (Flk.) Mass.
  rangiferina (L.) Web.
  squamosa (Scop.) Hoffm.
  sylvatica (L.) Hoffm.
Stereocaulon pascale (L.) Fr.
Gyrophora Dillenii (Tuckerm.) Mull.
Sticta amplissima (Scop.) Mass.
  pulmonaria (L.) Ach.
Nephroma helveticum Ach.
Peltigera aphthosa (L.) Hoffm.
  canina membranacea Ach.
Pertusaria leioplaca (Ach.) Schaer.
  multipuncta (Turn.) Nyl.
Lecanora allophana Ach.
  pallida (Schaer.) Rabenh.
  subfusca (L.) Ach.
    parisiensis Nyl.
  varia (Ehrh.) Ach.
Nephromopsis ciliaris (Ach.) Hue
Cetraria lacunosa Ach.
  pinastri Fr.
  saepinicola (Ehrh.) Ach.
Parmelia conspersa (Ehrh.) Ach.
  olivacea Ach.
  physodes (L.) Ach.
  saxatilis (L.) Ach.
  sulcata Tayl.
  subaurifera Nyl.
  tiliacea Ach.
Everina furfuracea (L.) Mann.
Ramalina calicaris (L.) Fr.
    subfastigiata Nyl.
Usnea barbata (L.) Fr.
  longissima Ach.
Buellia disciformis (Fr.) Mudd.
  penobscotensis Merrill
Physcia obscura virella (Ach.) Leight.
  stellaris (L.) Nyl.

Frullania Selwyniana Pearson

On the bark of standing arbor vitae (Thuja occidentalis L.), Newcomb, *H. D. House,* June 6, 1922. Of frequent occurrence

in this section but only on the trunks of arbor vitae. Determined by Dr A. W. Evans, who states that he has no previous record of this hepatic from New York, although he has it from Vermont and Ohio. Barbour[1] records it only from Ohio and Canada.

Among other hepatics collected at Newcomb, and named by Doctor Evans, are:

Frullania eboracensis Gottsche
Frullania Asagrayana Mont.
Bazzania trilobata (L.) S. F. Gray
Porella platyphylla (L.) Lindb.
Ptilidium pulcherrinum (Web.) Hampe

Cypripedium arietinum R. Br.

Near Keeseville. *W. H. Roberts,* June 1, 1924.

Rosa Bushii Rydberg[2]

Old fields near Newcomb. *H. D. House 9079,* July 18, 1922, and collected again near the same place and in another field about a mile distant in 1923. The type of this species is from Courtney, Mo.

Thalictrum venulosum Trelease

Shore of Lake Champlain south of Westport. *H. D. House 10323,* July 12, 1924.

Geranium Bicknellii Britton

On rocks and ledges at Port Henry. *H. D. House 10326,* July 12, 1924, along with Potentilla inclinata Vill., no. 10327.

Phragmitis Phragmitis (L.) Karst.

Banks of the Hudson river just below the bridge at Newcomb. *H. D. House 10711,* September 21, 1924. The plants were rather small and few of them were fruiting. The altitude here is about 1550 feet, and I have no record of this at any higher altitude in the State.

Eleocharis olivacea Torrey

Muddy shores of the outlet of Lake Harris, Newcomb. *H. D. House 10730,* September 22, 1924.

Gnaphalium Macounii Greene

Along a wood road near Newcomb. *H. D. House 10697,* September 20, 1924. Perhaps not native here.

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[1] Bryologist 5: 5. 1902.
[2] North American Flora 22: 506. 1918.

Pyrola chlorantha Sw.

Paradox lake. *E. P. Killip 12585,* August 16, 1924.

Rosa Bourgeaniana Crepin

Westport, *C. H. Peck,* June and July 1892 (determined by Mrs Erlanson). Reported by Doctor Peck as Rosa Sayi.

Rosa serrulata Raf.

Mt Defiance near Ticonderoga, *C. H. Peck,* but designated by him as Rosa humilis (determined by Mrs Erlanson).

Rosa virginiana Mill

On ledges of rock, Port Henry, *House 10330,* July 12, 1924. This is the most northern record known in the state for this rose.

Plants collected at Lower Jay, Essex county. On July 11th, my attention was attracted to some outcropping ledges of rock close to the state highway near Lower Jay, upon which was conspicuous a number of Jack pines, Pinus Banksiana Lamb. The following list of plants collected at this spot is interesting as indicating the nature of the flora here. They are listed in the order of collection.

Pinus Banksiana Lamb.
Carex brevior (Dewey) Mackenzie
Clinopodium vulgare L.
Panicum huachucae silvicola Hitchc. & Chase
Carex normalis Mackenzie
Potentilla arguta Pursh.
Panicum latifolium L.
Ribes Cynosbati L.
Cornus femina Mill.
Selaginella rupestris (L.) Spreng.
Woodsia Ilvensis (L.) R. Br.
Anemone virginiana L.
Quercus rubra L.
Minuartia Michauxii (Fenzl.) Farwell
Rhus typhina L.
Ranunculus fascicularis Michx.
Carex blanda Dewey
Geranium carolinianum L.
Panicum tsugetorum Nash
Potentilla argentea L.
Woodsia obtusa (Spreng.) Torrey
Specularia perfoliata (L.) A. DC.
Filix fragilis (L.) Underw.
Capnoides sempervirens (L.) Borck.
Silene antirrhina L.
Carex cephalophora Muhl.
Ostrya virginiana (Mill.) K. Koch.
Ribes rotundifolia Michx.
Panicum implicatum Scribn.
Agrostis palustris Huds.

Agrostis hiemalis (Walt.) B. S. P.
Epilobium palustre L. Var.
Myosotis virginica (L.) B. S. P.
Juncus secundus Beauv.
Carex platyphylla Carey
Galium circaezans Michx.
Polygala polygama L.
Cardamine parviflora L.
Festuca obtusa Spreng.
Hystrix Hystrix (L.) Millsp.
Danthonia spicata (L.) Beauv.
Antennaria neodioica Greene
Carex heterosperma Wahl. (anceps)
Carex radiata (Wahl.) Dewey
Carex convoluta Mackenzie
Juniperus depressa Pursh
Panicum linearifolium Scribn.
Comptonia peregrina (L.) Coulter
Oenothera pumila L.

This list of plants is remarkable for only a few items. It was entirely unexpected to find in this section of the State undoubted specimens of Geranium carolinianum, Panicum latifolium, Woodsia obtusa and Polygala polygama.

Hamilton county

Betula coerulea Blanchard

In rather poor soil, along Indian lake road about 2 miles from Blue mountain lake. *H. D. House 10576,* August 19, 1924.

Alnus viridis var. **Fernaldii** House

(Alnus mollis Fernald)

Sandy soil, near Little Tupper lake. *H. D. House 10681,* September 19, 1924.

Solidago Randii (Porter) Britton

Sandy soil, Little Tupper lake. *H. D. House 10690,* September 19, 1924.

Aster novi-belgi L.

Common in various situations at Little Tupper lake. *No. 10688* with white rays, and more nearly entire leaves than the common form; *no. 10687* with reddish-purple rays, nearly the color of those in Aster novae-angliae f. roseus; *no. 10680* with light-blue rays. Forms with pink rays, intermediate between *10688* and *10687* were also noted.

Aster Blakei (Porter) House

Marshy border of a small pond about 6 miles east of Long lake. *H. D. House 10679,* September 19, 1924. This was first mentioned

by Peck as A. nemoralis var. major (47th Rep't N. Y. State Mus. 155. 1894), and described at about the same time by Porter as A. nemoralis var. Blakei (Torr. Club Bul. 21: 311. 1894). It is undoubtedly a hybrid between Aster acuminatus and A. nemoralis, as indicated in the Annotated List (p. 711).

Plants collected on Long lake. The road at Long lake crosses a small island, and from the south end of this island there extends at low water a gravelly bar (sandy on the inside) to the mainland, which at this point is covered with a stand of Norway pine (Pinus resinosa Ait.). This bar cuts off a small shallow bay which in late summer is well filled with various forms of water loving plants. The entire area including the small island, the pine woods and the bay would not exceed 2 acres. The following plants were collected here, listed in the order of collection, the place being visited 3 times during the season of 1924:

Gaylussacia baccata (Wang.) K. Koch.
Carex oligosperma Michx.
Carex exilis Dewey
Veronica serpyllifolia L.
Pinus resinosa Ait.
Aronia melanocarpa (Michx.) Britton
Prunus depressa Pursh
Alnus incana (L.) Medic.
Alnus viridis (Chaix) DC.
Viola lanceolata L.
Amelanchier sanguinea (Pursh) DC.
Comarum palustre L.
Salix pedicellaris Pursh
Vaccinium canadense Kalm
Vaccinium angustifolium Ait.
Carex lenticularis Michx.
Juniperus communis var. depressa Pursh
Oryzopsis pungens (Torr.) Hitchc.
Sanicula marilandica L.
Potentilla tridentata Ait.
Arctostaphylos uva-ursi (L.) Spreng.
Comptonia peregrina (L.) Coulter
Carex vesicaria var. monile (Tuckerm.) Fernald
Pyrola chlorantha Sw.
Sorbus americana Marsh.
Oryzopsis asperifolia Michx.
Cornus stolonifera Michx.
Chimaphila umbellata (L.) W. Barton
Ilexverticillata var. tenuifolia Torrey
Aster junceus Ait.
Sium cicutaefolium Schrank
Calamagrostis inexpansa A. Gray
Spartina Michauxiana Hitchc.
Scirpus americanus Pers.
Scirpus Torreyi Olney
Cyperus dentatus Torrey
Melampyrum lineare Lam.
Apocynum androsaemifolium L.

Panicum spretum Schultes
Drosera rotundifolia L.
Drosera intermedia Hayne
Carex cryptolepis Mackenzie
Andropogon scoparius Michx.
Lysimachia terrestris (L.) B. S. P.
Calamagrostis canadensis L.
Hypericum boreale (Britton) Bicknell
Solidago Randii (Porter) Britton
Carex viridula Michx.
Sanguisorba canadensis L.

Prunus depressa has been collected here by Peck as well as by others. It is a very conspicuous thing on the shore of the lake. Quite unexpected were the four grasses: Calamagrostis inexpansa, Spartina Michauxiana, Andropogon scoparius and Panicum spretum. All of the other species in this list are more or less characteristic of the lake shores in this region.

Herkimer county

Cephalozia planiceps (Austin) Lindb.

In sphagnum bog, near Little Moose lake. *C. C. Haynes 1588,* August 2, 1913.

Cephaloziella Hampeana (Nees) Schiffn.

On earth in rock crevices, Bald mountain. *C. C. Haynes* Hepat. Amer. No. 49, June 22, 1908.

Metzgeria pubescens (Schrank) Raddi

On granite boulders, Little Moose lake. *C. C. Haynes 1563,* July 31, 1913.

Carex Sprengelii Dewey

Rocky woods east of Little Falls. *H. D. House 10134,* June 23, 1924.

Vaccinium canadense L. f. **chiococcum** Deane

Near Old Forge. *E. W. Blue,* September 8, 1924. Fruit white or nearly so when mature, usually with a slight pinkish tint on one side.

Jefferson county

During the latter part of June 1922, a trip was made to the Black river region below Watertown. Extraordinary high water in the river made impossible the examination of many spots which in

ordinary seasons are botanically very interesting. Among the many plants collected only the following need be noted:

Camptosorus rhizophyllus (L.) Link
Cryptogramma Stelleri (Gmel.) Prantl.
Agropyron tenerum Vasey
Poa debilis Torrey
Panicum tennessense Ashe
Panicum xanthophysum A. Gray
Trisetum spicatum (L.) Richter
Danthonia compressa Austin
Bromus Kalmii A. Gray
Carex alopecoidea Tuckerm.
Carex brevior (Dewey) Mackenzie
Carex cephaloidea Dewey
Carex Deweyana Schw.
Carex grisea Wahl.
Carex eburnea Boott
Carex tenera Dewey
Quercus macrocarpa Michx.
Minuartia Michauxii (Fenzl.) Farwell
Geranium Bicknellii Britton
Symphoricarpos racemosus Michx.
Rhus aromatica Ait.
Rosa blanda Ait.
Houstonia longifolia Gaertn.
Aster ptarmicoides T. & G.
Arabis Drummondii A. Gray
Amelanchier stolonifera Wiegand
Viburnum affine Bush, var. hypomalacum Blake
Lepargyraea canadensis (L.) Greene
Comandra umbellata (L.) Nutt.
Fraxinus pubescens Lam.
Arctostaphylos uva-ursi (L.) Spreng.
Ceanothus americanus L.
Polygala Senega L.
Viola septentrionalis Greene
Arabidiopsis Thaliana (L.) Britton
Taenidia integerrima (L.) Drude

Carex Peckii E. C. Howe

Dry woods near Woodville. *H. D. House, 10083,* June 17, 1924.

Saururus cernuus L.

Sixtown pond and creek near Henderson. *H. D. House, 10066,* June 17, 1924. Plants not mature at this date. Flowering plants were secured here in July.

Potamogeton praelongus Wulf.

Pierrepont pond, an inlet from Lake Ontario, near Woodville. *H. D. House 10070,* June 17, 1924.

Poa saltuensis Fernald & Wiegand

Moist woods near Woodville. *H. D. House 10066,* June 17, 1924.

Smilax herbacea L.

The common form of the species in this State, and which I take to be the typical form of the species, has ovate leaves, rarely narrowly ovate, acute to acuminate and cuspidate at the apex, broadly obtuse, rounded or subcordate at the base, the broadest ones being broadest below the middle and more or less tapering to an abruptly rounded, blunt or acute apex.

var. **latifolia** House, var. nov.

Leaf blades broadly rounded or suborbicular, rounded at the cuspidate apex, entire, cordate or deeply cordate at the base, broadest across the middle of the blade, 2–3 inches long and as broad, or the lower leaves slightly broader than long, and the upper leaves slightly longer than broad, somewhat paler green beneath than on the upper surface, but neither downy nor distinctly glaucous.

Thickets on the sand dunes along the east shore of Lake Ontario, near Woodville. *H. D. House 8858,* June 20–21, 1922.

Lewis county

Eriophorum callithrix Cham.

Open marsh near Watson. *H. D. House 10100,* June 18, 1924.

Polemonium VanBruntiae Britton

Alder swamp west of Parkers (township of Montague), *Neil Hotchkiss 661,* July 1, 1923. Heretofore known only from a few localities south of the Mohawk valley in the counties of Delaware, Ulster, Otsego, Herkimer and Madison.

Antennaria Parlinii Fernald

Thin woods near Copenhagen. *H. D. House 10093,* June 18, 1924.

Madison county

Asarum acuminatum (Ashe) Bicknell

Rich leafmold in dense mixed forest of hemlock and hardwoods, on Helderberg limestone formation, about 2 miles south of Oneida, at an altitude of about 1000 feet. *H. D. House 10018,* June 12, 1924. This was described as a campestrian species, but its habitat here is anything but that. The state herbarium also contains a specimen collected by H. B. Lord at Ludlowville, Tompkins county.

Rubus Baileyanus Britton

Roadside thicket near Oneida. *H. D. House 10038a,* June 15, 1924.

Saxifraga pennsylvanica L.

A. M. Johnson described Saxifraga purpuripetala in 1919 (Minn. Biol. Stud. 4: 51), citing specimens from Vermont and New Jersey. Type specimens have not been examined but from the description it appears to differ from S. pennsylvanica, chiefly by its purple petals. Various colonies of the swamp saxifrage were examined during 1923 and 1924 and the search was rewarded by finding the plant described by Johnson rather abundant in the swamps around Peterboro. Here it grows with the typical form of S. pennsylvanica which has dull creamy yellow petals, almost white in dried specimens. It can not be regarded as more than a color form of the species, characterized by its reddish or rosy purple petals and yellow to orange colored anthers, and may be designated as forma purpuripetala (Johnson) comb. nov.

Botrychium angustisegmentum (Pease & Moore) Fernald

In low woods near White's Corners, town of Eaton. *H. D. House,* June 24, 1924.

Oneida county

Thelypteris Goldiana (Hook.) Nieuwland

Moist, wooded bank along the headwaters of the Mohawk river near Dunn brook, town of Western. *H. D. House 10112,* June 18, 1924.

Carex Frankii Kunth

Wet, open woods, east of Oneida. *H. D. House 10812,* October 28, 1924. This sedge was reported from here in the Annotated List (p. 199) on the basis of three rather immature specimens collected here in 1918 and determined by Mr Mackenzie. Subsequent search failed to reveal more of it until this season when the search was extended into some nearby open, wet woods where it was found very abundant, and at this date mostly overmature, but numerous specimens were collected and have been distributed to several herbaria.

Arisaema Stewardsonii Britton

Low woods near Camden, *H. D. House 10040,* June 16, 1924. Also collected at Clayville, June 23, 1917. Distinctly a plant of the Alleghanian and lower Canadian zones in this State. Some authorities have apparently doubted whether this was distinct or not from A. triphyllum. Herbarium specimens lose much of their distinctive character in drying. After studying this in the field for

several seasons I am abundantly convinced that it is specifically distinct from A. triphyllum. The leaves are green beneath, never glaucous as in A. triphyllum, but the most distinct characters are found in the spathe, the tube of which is more attenuated at the base, white or whitish, externally, with pale green stripes, and deeply fluted, striped with brownish purple within, the upper portion and the acuminate apex of the spathe pale green and without stripes or other color on either side.

Mimulus Moschatus Dougl.

Moist shady places among rocks along Fish creek near Taberg, *Neil Hotchkiss 1820,* September 18, 1924.

Rubus sativus (Bailey) Brainerd

Sandy thickets, edge of pine woods near North Bay. *H. D. House 10121,* June 21, 1924.

Onondaga county

Linum catharticum L.

Wet places in seepage along a brook in a pasture near Marcellus, *Neil Hotchkiss 703,* July 13, 1923. Native of Europe and reported as naturalized in Nova Scotia and Ontario. Not previously reported from this State.

Ontario county

Viola Baxteri House

Dr B. L. Robinson has generously called my attention to the fact that the citation for this species in the Annotated List (N. Y. State Mus. Bul. 254: 500), is incorrect, and that through some clerical error refers to Veronica Baxteri. The name Viola Baxteri should have been indicated there as a new species, based upon the description of V. perpensa given in N. Y. State Mus. Bul. 197: 58. 1918, which proves to be a misidentification of the plants collected by Baxter. Although obviously allied to Viola palmata L. it seems to be in the writer's opinion specifically distinct from that species.

Orange county

Castilleja coccinea (L.) Spreng.

Near Port Jervis. *Emelie A. Salisbury,* June 4, 1924.

Oswego county

Serapias Helleborine L.

Riverside cemetery woods near Oswego. *E. P. Killip 12520,* August 8, 1924.

Salix syrticola Fernald

On sand dunes along the shore of Lake Ontario, at Selkirk (Port Ontario). *H. D. House 10060,* June 16, 1924. This was first collected on the shore of Lake Ontario near Woodville, Jefferson county, in 1921 and 1922 by the writer. As no reports for those years have been published the report of it first appears in the Annotated List (p. 264). Meanwhile Fernald and Wiegand reporting upon plants collected during 1923 in the Ontario and St Lawrence basins record Salix syrticola from the same general region (Rhodora 25: 205–14. 1923).

Rensselaer county

Sparganium chlorocarpum Rydberg

Glasshouse lake. *H. D. House 10427,* August 2, 1924.

Pinus resinosa Ait.

East Postenskill. *H. D. House 10360,* July 19, 1924.

Spiraea tomentosa forma **albiflora** (Raf.) Macbride

East Nassau. *H. D. House 10435,* August 2, 1924. In one marsh, the white flowered form of this species was found to the entire exclusion of the usual red flowered typical form.

Mentha canadensis var. **glabrata** Benth.

Shore of Tomhannock reservoir. *H. D. House 10616,* August 29, 1924.

Dracocephalum virginicum L.

Roadside, town of Brunswick. *H. D. House 10615,* August 29, 1924. Conditions pointed to the suspicion that the species had been introduced here and was not native.

Rosa obovata Raf.

Edge of pine woods, Averill Park, *House 10356,* July 19, 1924.

Rosa virginiana Mill

Pine woods near Valley Falls, *House 8398,* 1921. This and the preceding species determined by Doctor Rydberg and Mrs Erlanson.

Viola fimbriatula J. E. Smith

Among the hybrid violets in this group, in addition to those already listed in the Annotated List (p. 505–6), is the following, found growing with V. fimbriatula and V. latiuscula Greene, in open woods in the eastern portion of the town of Brunswick:

x **Viola Egglestoniana** hyb. nom. nov. (V. fimbriatula x latiuscula Brainerd, Bul. Vermont Agr. Exp. Station 239: 107. 1924).

Viola latiuscula Greene

As noted above, this species was found in the town of Brunswick. Brainerd (l. c. 137) reports a hybrid between this species and Viola sororia from near Hoosic Junction, which following the binomial characterization adopted in the Annotated List, may be designated as x **Viola vermontana** hyb. nom. nov.

Richmond county

Among the violet hybrids overlooked in compiling the species for the Annotated List of New York plants, are the following:

x **Viola Dowelliana** hyb. nom. nov. (Viola affinis x hirsutula Dowell, Torrey Club Bul. 37: 171. 1910). Egbertville, Staten Island. *Dowell* (See Brainerd, l. c. 27).

x **Viola egregia** hyb. nom. nov. (Viola Brittoniana x sororia Dowell, Proc. Staten Island Assoc. 3: 161. 1911). Staten Island. *Dowell.*

Saratoga county

Panicum Scribnerianum Nash

Sandy soil, roadside, near Bemis Heights. *H. D. House 10334,* July 12, 1924.

Agropyron tenerum Vasey

Sand plains south of Glens Falls. *H. D. House 10150,* June 30, 1924. Det. Chase.

Verbena angustifolia Michx.

Sand plains south of Glens Falls. *H. D. House 10144,* June 30 and September 18, 1924.

Bidens trichosperma (Michx.) Britton

Low ground near Wilton. *Mrs O. P. Phelps,* September 13, 1924. Perhaps introduced from farther south.

Suffolk county

Draparnallia acuta (Ag.) Kutz.

This alga, determined by Hazen, was found in fresh water pools near Mattituck. *Roy Latham,* March 1, 1924.

Carex silacea Olney

Southampton beach. *H. D. House 9737,* August 15, 1923.

Rosa Bicknellii Rydberg

Yaphank. *C. H. Peck.* September (1889). Det. Rydberg.

Rosa Lyoni Pursh

Montauk Point. *H. D. House 9728,* August 15, 1923. West Hampton. *Peck.* Also collected at Merrick, Nassau county. *H. D. House,* June 21, 1916 and photographed as Rosa virginiana in the Wild Flowers of New York. Northward in the State this has been collected at Pine Plains, Dutchess county, *Peck;* Glenmont, Albany county, *House 6573,* July 29, 1919, and Helderberg mountains, *Peck.* All of the specimens cited determined by Doctor Rydberg.

Cephalozia macrostachya Kall.

In a sandy bog near Southold. *Roy Latham,* September 25, 1915.

Tioga county

Calamagrostis Porteri A. Gray

Apalachin. *F. E. Fenno,* July 20, 1900. Sent to the state herbarium as C. cinnoides, but recently determined by Mrs Chase as C. Porteri, heretofore known in this State only from Sullivan hill, Chemung county, collected by *T. F. Lucy* in 1895.

Tompkins county

Carex cryptolepis var. **prolifera** (H. B. Lord) comb. nov.

Carex irregularis Schw. Ann. Lyc. N. Y. 1: 66. 1824
Carex Oederi var. prolifera H. B. Lord, 19th Rep't N. Y. State Mus. 76. 1866

Ludlowville. *H. B. Lord* (type or cotype in herbarium of N. Y. State Museum). Marl pond outlet, Cortland county, *Peck.* Lake Harris, Essex county, *House.*

This variety seems to be always associated with C. cryptolepis, which has had a very checkered nomenclatorial career. Often designated as a variety of C. flava L., or C. Oederi Retz, it seems first to have been described by Michaux as C.

Oederi, but is not the C. Oederi of Europe. Dewey called it C. lepidocarpa, an untenable name; the seventh edition of Gray's manual designated it as C. flava var. rectirostra; and lastly Mackenzie has described it as Cares cryptolepis (Torreya 14: 157. 1914; N. Y. State Mus. Bul. 254: 195. 1924).

Asarum acuminatum (Ashe) Bicknell

Ludlowville. *H. B. Lord* (see under Madison county).

Trollius laxus Salisb.

Near Malloryville. *F. A. Ward,* July 26, 1924. Mr Ward also sends specimens of the three following species collected at Malloryville:

Limnorchis hyperborea (Nutt.) Rydb.
Cypripedium reginae Walt.
Cirsium muticum Michx.

Ulster county

Webera sessilis (Schmid.) Lindb.

On ground in woods, Vernooy kill camp (Potterville), about 1000 feet altitude. *H. D. House,* August 8, 1922. In the state herbarium this is labelled by Doctor Peck as Diphyscium foliosum Web. & Mohr., the specimens being from Gansevoort and Sandlake, collected by Doctor Peck. Burnham (Bryologist 23: 23. 1920) reports it from Washington county.

Rosa obovata Raf.

Dry woods, Napanoch. *H. D. House 8545, 8546,* August 19–21, 1921. Determined by Rydberg.

Warren county

Sparganium minimum Fries

Edge of a small pond near Chestertown. *H. D. House 10455,* August 8, 1924, growing with Eriophorum tenellum Nutt. and Andromeda glaucophylla Link.

Carex Merritt-Fernaldii Mackenzie

In sandy soil near roadside, Chestertown. *H. D. House 10459,* August 8, 1924.

Pentstemon pallidus Small

On dry banks near roadside, Loon Lake, near Chestertown, *H. D. House 10154,* June 30, 1924. Like its closely related species, P. hirsutus, probably adventive from the south.

VEGETATION OF THE EASTERN END OF ONEIDA LAKE

SUPPLEMENTARY ACCOUNT

Since the publication of the account of the Vegetation of the Eastern End of Oneida Lake[1] in 1918, additional records have accumulated as a result of further investigations carried on in this region, from a study of specimens collected there and particularly as a result of numerous visits during the past few seasons to the extensive sand plains situated east of the lake.

In the publication just mentioned the writer strongly emphasized (p. 65–68) the austral elements of this vegetation, and the statements made that "the mere age of a geologic formation is of little consequence in determining the character of plant growth. The important factor is the lithologic characters, mechanical and chemical, irrespective of age. A sandy soil, whether a recent dune or one derived from the disintegration of Triassaic or Paleozoic sandstones, is the home of similar sand loving plants, where moisture conditions are the same, however much the areas may differ in altitude within given limits, or in latitude within certain limits and modifications."

Dr Donald Culross Peattie[2] studying the Atlantic coastal plain element in the flora of the Great lakes, assembles a mass of geological data tending to indicate that the coastal plain element of the flora of the Great lakes and especially about Oneida lake, reached this region by migration through the outlets of the glacial lakes, and in the case of Oneida lake, through the Hudson-Mohawk valley outlet of the early stages of Lake Iroquois.

This view is eminently logical and doubtless approximates very closely the true explanation. The writer believes that Doctor Peattie's explanation in no way invalidates the writer's statements:[3] "If we are to consider the various elements of our flora as having migrated northward after the retreat of the ice sheet of the glacial epoch, it is apparent that the first advance forward of any element of the flora at any time will follow the line of least resistance, which means favorable soil conditions, rather than unfavorable conditions, where the climatic influences are otherwise identical." For this reason it is almost axiomatic that the region of sandy plains and its more or less undrained marshes and depressions, which soon developed into acid or marly bogs, should be occupied more quickly

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[1] New York State Mus. Bul. 197: 61–110. 1918.
[2] Rhodora 24: 57–70; 80–88. April, May 1922.
[3] House. l.c. p. 66.

and easily by plants migrating from somewhat similar conditions on the coastal plain, rather than by plants from the adjacent Appalachian highlands to the south, where the soils were presumably gravelly drifts, clays and cold humus.

In passing, it should be remarked that the following plants in Doctor Peattie's list should be definitely listed as occurring in the Ontario lowlands, and their inclusion adds strength to his argument:

Andropogon scoparius	Rynchospora macrostachya
Panicum spretum	Nelumbo lutea
Panicum meridionale	Cakile edentula
Panicum albemarlense	Hydrocotyle umbellata
Echinochloa Walteri	Linaria canadensis
Ammophila arenaria	Cirsium odoratum
Eleocharis interstincta	

I would add to Doctor Peattie's list the following plants which occur in the Oneida lake region or in the Ontario lowlands of New York, as additional elements of the coastal plain flora to be found in the region of the Great lakes:

Azolla caroliniana	Meibomia Michauxii
Cyperus filiculmis	Sarothra gentianoides
Scleria triglomerata	Rhexia virginica
Panicum Lindheimeri	Nyssa sylvatica
Panicum Ashei	Trichostema dichotoma
Panicum agrostoides	Aster linearifolius
Panicum tennessense	Panicum aculeatum
Habenaria ciliaris	Carex tonsa
Saururus cernuus	Carex laevivaginata
Comptonia peregrina	Cenchrus pauciflorus
Ibidium gracilis	Ipomoea pandurata
Sassafras Sassafras	

Regarding some of the other plants mentioned in Doctor Peattie's list, there is a measure of doubt regarding either their being characteristic plants of the coastal plain flora or their occurrence in the Ontario lowlands, as for example:

Nias gracillima. Once collected near Albany, but unknown from the Ontario lowlands.

Carex exilis. This is, of course, occasional on the Ontario lowlands, but is, like Viola lanceolata, Sanguisorba canadensis, Lycopodium inundatum, Utricularia resupinata and a number of other species, more characteristic of lake shores or acid bogs of the Adirondack plateau region, as well as the coastal plain, and their migrations northward, if it be assumed that such migrations have taken place, have evidently followed along a different series of influences than merely along the sandy and shore influences of the outlets of the glacial lakes.

Orontium aquaticum. This occurs in the Hudson river northward to Saugerties, has been collected many years ago in Fulton

county north of the Mohawk valley, and is found sparingly in the upper Susquehanna region (Clute), but I know of no records for it in the Oneida lake region or in the Ontario lowlands of this State.

In the following notes and additions to the list of plants of the eastern end of Oneida Lake, those species preceded by a star (*) have not been previously reported from this region.

Ophioglossum vulgatum L.

Typical specimens were found near Fort Bull, west of Rome, and are not uncommon about Sylvan Beach. In the sterile soil of sandy depressions specimens are sometimes found which measure little more than 5 or 6 cm in height, but are fertile. Such plants apparently represent what was described by Rafinesque[4] as O. pusillum, and by Beck[5] as O. Grayi. Gradations between them and the typical form of the species often occur in the same spot, so that it is apparent that these dwarfed forms have little systematic value, but have been designated as O. vulgatum forma pusillum.[6]

Dryopteris simulata Davenport

An additional locality for this rare fern was discovered in low, sunny woods and an open, marshy clearing adjacent to the woods, about 2 miles north of New London, July and August 1918. The fern is very abundant here and the locality is about 4 miles east of Sylvan Beach, where it was found several years ago[7] and where it still grows in a very limited area and in danger of extermination by the building of cottages and the filling in of the low ground.

Picea rubens Sargent

In low woods about 3 miles north of New London, at an altitude of only 400 feet, occur numerous red spruce trees from 4 to 10 inches in diameter at the base, and some of them 40 to 60 feet tall. Only a few scattered seedling trees had been previously found near Sylvan Beach.

***Larix laricina** (DuRoi) Koch

Reported by W. C. Muenscher[8] from near Sylvan Beach and from the marshes in the sand plains a few miles east of the lake, where it was also seen in 1922 by the writer.

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[4] Jour. Bot. Desv. (II) 4: 273. 1814.
[5] Bot. N. & Mid. States 458. 1833.
[6] House. New York State Mus. Bul. 243–44: 42. 1923.
[7] House. Torreya 3: 116. 1903.
[8] Letter dated December 2, 1922.

***Lycopodium clavatum var. megastachyon** Fernald & Bissell

In low woods near New London. *H. D. House,* July 15, 1918.

***Equisetum laevigatum** A. Br.

Sandy shores of Oneida lake, at Sylvan Beach. *H. D. House 5450,* June 5, 1914. Previously reported as E. hyemale intermedium. Doctor Haberer has also collected a proliferous branched form at Oneida lake.[9]

***Typha angustifolia** L.

Common along the shores of Oneida lake at South Bay, Madison county, and elsewhere along the south shore of the lake and more rarely inland east of the lake. Most of the plants growing along the lake belong to the so-called variety longispicata Peck.[10]

Typha latifolia L.

In 1886 Professor Dudley[11] described from the Cayuga marshes a variety "elongata," of the common cat-tail. The specimens in the state herbarium from the Cayuga marshes, sent by Professor Dudley, and which presumably represent his variety, since they are so labeled by him, have the pistillate spikes 20–23 cm long, and 2–2.5 cm thick. Professor Dudley states that the leaves are 2–3½ mm wide, but the specimens in the state herbarium have leaves 5–10 mm wide and convex. It is quite possible that his elongata occurred in both Typha latifolia and T. angustifolia. The same extreme occurs in specimens of both Typha latifolia and Typha angustifolia in the Oneida lake region, and in both cases numerous gradations between forms with very long pistillate spikes and forms with very short pistillate spikes are not lacking.

***Potamogeton americanus** C. & S.

In shallow water. South Bay, Madison county. *H. D. House 1917.*

***Potamogeton bupleuroides** Fernald

Oneida lake, off Verona beach lighthouse. *W. C. Muenscher 14534,* September 13, 1922.

Scheuchzeria palustris L.

Abundant in an extensive bog on the sand plains about 6 miles west of Rome, July 12, 1919. Kneiskern reported this species as abundant in the swamps near Rome many years ago.

[9] New York State Mus. Bul. 243–44: 47. 1923.
[10] 47th Rep't N. Y. State Mus., 162 (Bot. ed. 36). 1894.
[11] Dudley. Cayuga Flora 102. 1886.

***Sagittaria rigida** Pursh

In shallow water and on wet sandy beaches, near the mouth of Oneida creek, Madison county. *H. D. House 8290,* June 27, 1921.

***Sparganium acaule** (Beeby) Rydberg

Banks of Fish creek, above Fish Creek Landing. *W. C. Muenscher 14531,* September 17, 1922.

Panicum xanthophysum A. Gray

Very common in the pine barrens, 2 to 3 miles north of New London, where collected on July 19, 1918.

***Panicum aculeatum** Hitchc. & Chase

Sandy thickets along the shore of Oneida lake, near Sylvan Beach. *H. D. House 8140,* June 20, 1921.

***Panicum Tuckermani** Fernald

Reported by W. C. Muenscher from near the shore of Oneida lake at South Bay, Madison county, *no. 14557,* September 14, 1922. For a discussion regarding the status of this grass see New York State Museum Bulletin 254 : 74. 1924.

Echinochloa Crusgalli var. **Michauxii** House

Known also under the name of E. muricata (Michx.) Fernald. Common near Sylvan Beach. *H. D. House,* September 18, 1916. The form described by Wiegand as E. muricata var. microstachya, is reported from Sylvan Beach by W. C. Muenscher.[8]

***Oryzopsis asperifolia** Michx.

Frequent in the dry pine woods and clearings north of New London, often in company with Panicum xanthophysum.

***Oryzopsis pungens** (Torrey) Hitchc.

Open, sandy woods often under pine trees, north of New London. *H. D. House 8307,* June 28, 1921.

***Bromus inermis** Leyss.

In waste ground near Sylvan Beach. *H. D. House 5501,* June 8, 1914. Adventive or naturalized.

***Elymus virginicus** var. **hirsutiglumis** (Scribn.) Hitchc.

Near the lake shore at North Bay, Oneida county. *W. C. Muenscher 14580,* September 15, 1922.

***Eragrostis Frankii** Steud.

Reported from Fish creek, near the eastern end of Oneida lake, by W. C. Muenscher.

***Eriophorum callithrix** Cham.

Very abundant in a bog on the sand plains about 4 miles northwest of Rome, and in another bog about 6 miles west of Rome and 1 mile north of the barge canal. Collected during the summers of 1918 and 1919.

***Scirpus cyperinus** var. **pelius** Fernald[12]

Reexamination of the specimens collected at Oneida lake shows that typical Scirpus cypedrinus has not been collected there although I have no doubt it may occur there rarely. All of the collections made belong to the variety pelius, which seems to mature here a week or 10 days earlier than the forma congestus House.[13]

Carex oligosperma Michx.

Previously reported on the authority of Kneiskern and Paine. On July 12, 1919, found in abundance throughout large bogs of the sand plains about 6 miles northwest of Rome, and probably in about the same locality where it was said by Paine to be common.

Carex Asa-Grayi Bailey

Moist sandy woods along the shore of Oneida lake, north of Sylvan Beach. *H. D. House 8127,* June 21, 1921.

***Carex leucorum** Willd.

Common in sandy fields north of New London. *H. D. House 6099,* June 4, 1919. Commonly regarded as a variety of Carex pennsylvanica Lam.

***Carex tonsa** (Fernald) Bicknell

Frequent in sandy fields north of New London, and throughout most of the sandy plains east of Oneida lake. *H. D. House 6100,* June 4, 1919.

***Carex laevivaginata** (Kukenth.) Mackenzie

Collected near Verona several years ago by Doctor Peck, and more recently at several localities in Oneida and Madison counties. Not rare in the low woods east of Oneida lake.

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[12] Rhodora 8 : 164. 1906.
[13] New York State Mus. Bul. 254:150. 1924.

***Carex incomperta** Bicknell

Low woods near Sylvan Beach. *H. D. House,* June 17, 1918.

Carex rosaeoides E. C. Howe

Sylvan Beach, Oneida county. *H. D. House,* June 8, 1914. The determinations of all of the species of Carex here reported were made by Kenneth Mackenzie.

***Cyperus diandrus** Torrey

Reported from Sylvan Beach, by W. C. Muenscher.[8]

***Cenchrus pauciflorus** Bentham[14]

Common in sandy fields near Sylvan Beach. *H. D. House 5832,* August 10, 1914, and also reported from Fish creek by W. C. Muenscher.[8] This species was formerly called Cenchrus tribuloides, until 1908, when Professor Hitchcock[15] applied the name C. carolinianus Walter to the plant. The species is native of the southern and southwestern states, and has migrated northward, following sandy soils, along the coastal plain to New York and Massachusetts. It had appeared on the sandy plains between Albany and Schenectady as early as 1835[16] and was also reported from there by Paine,[17] but Paine does not mention having found it at Oneida lake, and it may be assumed that the plant has reached Oneida lake since 1865.

***Juncus articulatus** var. **stolonifer** (Wohlleb.) House[18]

Growing on moist or wet sandy beaches near Lewis Point, south shore of Oneida lake. *H. D. House,* October 21, 1920.

***Juncus marginatus** Rostk.

In an old stone quarry near Verona. *H. D. House,* August 26, 1918. Determined by Coville.

***Clintonia borealis,** forma **albicarpa** Killip

Occasional in low wet woods about 3 miles north of New London.

***Streptopus amplexicaulis** (L.) Michx.

Frequent in the deep swamps and low woods along Wood creek, north of New London.

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14 Hitchcock & Chase. Contr. U. S. Nat. Herb. 22:67. 1920.
15 Hitchcock. Contr. U. S. Nat. Herb. 12:127. 1908.
16 James Eights. The Albany Zodiac. 1835.
17 J. A. Paine jr. Cat. Pl. Oneida Co. & Vic. 174. 1865.
18 New York State Mus. Bul. 254: 213. 1924.

Smilax hispida Muhl.

Reported by *W. C. Muenscher*,[8] from Sylvan Beach.

Cypripedium arietinum R. Br.

Moist woods on the sand plains east of Oneida lake, and about 5 miles east of Sylvan Beach, and 6 or 7 miles northwest of Rome, near Humaston station. *Frederick B. Hodges*, June 10, 1922. This may be the same locality discovered by Asa Gray[19] or at least the same general region. After more than three-quarters of a century, with all the intervening devastation resulting from lumbering and fire, it is interesting to find this rare orchid still flourishing here. On June 28, 1922, Mr Hodges conducted me to the spot where I was able to note a number of vigorous plants.

***Blephariglottis Blephariglottis** (Willd.) Rydberg

Frequent in an extensive bog which occupied one of the numerous undrained depressions in the sand plains about 6 miles northwest of Rome.

***Ibidium plantagineum** (Raf.) House

Marshy shores of Oneida lake at South Bay, Madison county, and on mossy banks about 4 miles northwest of Rome, in the pine plains. Ibidium gracile (Bigel.) House, previously reported from Sylvan Beach, is frequent throughout all of this region in open sandy fields and pine woods.

***Peramium tesellatum** (Lodd.) Heller

In pine woods about 3 miles north of New London, Oneida County. *H. D. House*, July 15, 1918.

Comptonia peregrina (L.) Coulter

Previously reported upon the authority of Kneiskern. Since then the species has been seen abundantly in open pine woods and on sandy plains throughout most of the pine plain region north of New London and along the " Oswego road " northwest of Rome toward Humaston.

Quercus ilicifolia Wang.

Common in the sand plains northwest of Rome along the so-called " Oswego road " toward Humaston. *H. D. House 8298*, June 28, 1921. Subsequently seen in a few other sections of the pine plains,

[19] Torrey. Fl. N. Y. 2: 288. 1843.

and also about one-half mile east of Verona beach on the east shore of Oneida lake. It was also collected north of New London by *W. A. Matthews 2215*, July 18, 1922. These collections remove all doubt as to the correctness of Paine's report,[20] which may have been overlooked by Sargent who states that the range of this species "apparently does not reach central New York."[21]

*Populus alba L.

An introduced tree, native of Europe, reported by *W. C. Muenscher*[8] from Fish Creek Landing.

*Populus candicans Ait.

Frequently planted at Sylvan Beach, and rarely elsewhere in this region. *W. C. Muenscher*[8] reports it from Sylvan Beach, perhaps as an escape from cultivation.

*Salix sericea Marsh.

Low ground near Sylvan Beach. *H. D. House,* May 16, 1918. Also reported from the same locality by *W. C. Muenscher.*[8]

*Salix Bebbiana Sargent

Common in low woods and thickets near Sylvan Beach. *H. D. House,* May 16, 1918.

*Salix tristis Ait.

Frequent on the sand plains north of New London. *H. D. House 6873,* May 21, 1920.

*Salix longifolia Muhl.

Near Sylvan Beach. *W. C. Muenscher 14669,* September 13, 1922.

*Alsine aquatica (L.) Britton

An introduced species common along the old Erie canal, about 1 mile west of the site of old Fort Bull. In flower on July 20, 1918.

*Sedum purpureum Tausch.

An introduced species frequent along roadsides and railroads about South Bay, Madison county and at Fish creek, Oneida county.

*Ribes cynosbati L.

Frequent in woods about 3 miles north of New London.

[20] Paine. l.c. p. 126.
[21] Sargent. Silva of N. Amer. 8 : 156 (footnote 4). 1895.

*Ribes hirtellum Michx.

Swamp near Sylvan Beach. *W. C. Muenscher 14734,* September 17, 1922.

*Potentilla arguta Pursh

Sand plains about 3 miles north of New London. A single plant found, which appeared as though it might be adventive here.

*Crataegus macrantha Loddiges

North Bay, Oneida county, according to *W. C. Muenscher.*[8]

*Trifolium arvense L.

Common along railroad tracks and on sandy banks at several localities. Native of Europe.

Polygala polygama Walter

Common in the sand plains 2 or 3 miles north of New London, which is probably in about the same locality from which it was reported by Kneiskern in Paine's flora. A single clump with white flowers (forma albiflora House) was seen.

*Viola papilionacea Pursh

Roadsides and in low woods along Oneida creek near its mouth. Common and variable.

*Viola septentrionalis Greene

Occasional or locally frequent in swampy woods north of New London. *H. D. House 6078,* June 4, 1919.

*Kalmia latifolia L.

Forming large thickets along the edge of swampy woods and on decayed logs, occasionally in the more heavily wooded portions of the swamp, about 3 miles north of New London. August 26, 1918. This is apparently the only report of the mountain laurel in this region. Sartwell reports it from the head of Crooked lake, Yates county, and Bradley reports it from Ithaca.[22] Paine also reports it from near Utica and Oriskany, also in Oneida county, as in the New London locality, but in the Mohawk watershed, while the New London locality lies in the St Lawrence basin. Except for Hankenson's report[23] of this species from Sodus Bay, this is perhaps the most northern record for the mountain laurel in New York State.

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[22] Paine. l.c. p. 102.
[23] Proc. Rochester Acad. 3: 83. 1896.

*Kalmia Polifolia L.

Found in the same bog with Carex oligosperma Michx., and Blephariglottis Blephariglottis (Willd.) Rydb., but was apparently not detected here by Paine. *H. D. House 6076,* June 4, 1919.

*Andromeda glaucophylla Link

In the same bog with the preceding species, but not common, and collected on the same date.

Arctostaphylos uva-ursi (L.) Spreng.

This was included in the list of the Oneida lake plants upon the authority of Gray, who reported it from " near Oneida lake." On August 26, 1918, this species was found in abundance on the open sandy plains about 3 miles north of New London. This may be the locality indicated by Gray since a number of other species reported by Gray, Kneiskern and Paine, seem to occur now, at least, only in this portion of the sand plains and along the " Oswego road."

*Chiogenes hispidula (L.) A. Gray

Reported by *W. C. Muenscher*[8] from the swamps on the sand plains a few miles east of the eastern end of Oneida lake.

*Vaccinium corymbosum var. amoenum (Ait.) Gray

Reported from the vicinity of Sylvan Beach, by *W. C. Muenscher.*[8]

*Asclepias exaltata (L.) Muhl.

Open woods on the sand plains about 3 miles north of New London. *H. D. House 8299,* June 28, 1921.

Convolvulus spithamaeus L.

Common in thin woods and in sandy, grass covered fields, of the plains about 3 miles north of New London.

*Solanum carolinense L.

Sandy fields near Sylvan Beach. Apparently of rather recent introduction.

*Trichostema dichotomum L.

Common in sandy fields and meadows along Telin's brook, and elsewhere, about 3 miles north of New London. August 27 1918.

*Mentha piperita L.

Reported by *W. C. Muenscher*[8] from Fish Creek Landing.

***Verbascum Lychnitis** forma **album** (Mill.) House

Occasional with the typical form of the species in fields near Sylvan Beach.

Lobelia Kalmii L.

Very common on the gravelly shores of Oneida lake at Lewis Point, and occasionally elsewhere along the south shore of Oneida lake. August 20, 1918.

***Campanula uliginosa** Rydberg

Plants which appear to correspond to the description of this species are common along the south shore of Oneida lake, in wet places in sandy or gravelly soil, thickly overgrown with other low vegetation. *H. D. House 8360,* July 3, 1921.

***Solidago altissima** L.

Reported by *W. C. Muenscher*[8] from North Bay.

***Solidago patula** Muhl.

Reported by *W. C. Muenscher*[8] from Vienna on the north shore of Oneida lake. This species is abundant in wet places throughout this region and was inadvertently omitted from the list of plants found about the eastern end of Oneida lake.

***Solidago graminifolia** var. **galetorum** (Greene) House

Along the shore of Oneida lake this is apparently the representative form of the species, although inland from the lake the typical species is very common.

***Gnaphalium Macounii** Greene

Uncommon in the sandy fields and plains north of New London. September 2, 1918.

***Helenium latifolium** Mill.

Thickets along the shore of Oneida lake north of Sylvan Beach. *H. D. House 8705,* September 13, 1921. Also seen in October 1923, just north of the mouth of Oneida creek. These plants accord fairly well with the description by Rydberg,[24] except that the heads are chiefly solitary on long, slender peduncles. A more complete description of these plants has already been published.[25]

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[24] North American Flora 34: 127. 1915.
[25] House. New York State Mus. Bul. 254: 730. 1924.

***Cirsium odoratum** (Muhl.) Britton

Frequent in the thin pine woods on the sand plains about 3 miles north of New London. July 18, 1918.

***Rubus sativus** (Bailey) Brainerd

Edge of sandy woods, North Bay, Oneida county. *H. D. House 10121,* June 21, 1924.

***Rosa palustris** Marsh.

Wet soil, edge of sand plains west of Rome. *H. D. House,* July 20, 1918 (determined by Rydberg).

NOTES ON FUNGI, IX

Aecidium Dicentrae Trelease

On leaves of Capnorchis Cucullaria (L.) Planch. Van Cortlandt park and Williamsbridge, New York City. *Percy Wilson 52 & 230,* April 20, 1915 and April 28, 1916.

Bullaria Hieracii (Schum.) Arthur[1]

On basal leaves of Hieracium canadense Michx., Newcomb, Essex county. *H. D. House,* June 23, 1923.

Cintractia subinclusa (Korn.) Magnus

On pistillate spikes of Carex rostrata Stokes (C. utriculata Boott), Newcomb, Essex county. *H. D. House,* August 10, 1921. Collected by Doctor Peck at Lake Sallie, Essex county, on the same host and also on Carex oligosperma Michx.

Circinostoma S. F. Gray. Nat. Arr. Br. Pl. 1 : 521. 1821.

Calosphaeria Tul. Sel. Fung. Carp. 2: 108. 1863 — Sacc. Syll. Fung. 2: 95. 1883.

The type species is Circinostoma pulchellum S. F. Gray (Sphaeria pulchella Pers., Calosphaeria Princeps Tul.; Calosphaeria pulchella House, N. Y. State Mus. Bul. 233–34: 17. 1921.). Other New York State species are:

Circinostoma ciliatulum (Fr.) comb. nov. (Sphaeria ciliatula Fries; Calosphaeria ciliatula Karst.).

Circinostoma microspermum (E. & E.) comb. nov. (Calosphaeria microsperma E. & E.)

Circinostoma Myricae (C. & E.) comb. nov. (Valsa Myricae C. & E.; Calosphaeria Myricae E. & E.; Eutypella Myricae Sacc.)

Circinostoma scabrisetum (Schw.) comb. nov. (Sphaeria scabriceta Schw.; Eutypa scabriseta B. & C.; Calosphaeria scabriseta Sacc.)

Circinostoma microthecum (C. & E.) comb. nov. (Sphaeria microtheca C. & E.; Calosphaeria microtheca Sacc.)

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[1] Determined by Dr H. S. Jackson.

Clavaria amethystina (Battara) Bulliard

Jenny brook, Yama farms, Napanoch, Ulster county. *H. I. Miller* and *Dr F. B. Turck,* August 5, 1922. The specimen is a beautiful compact tuft, 4–6 cm tall. The dried material is a pale or dull lilac color.

Clavaria aurantio-cinnabarina Schw.

Fructifications simple, cespitose, fleshy, rather fragile and easily broken when fresh, as well as when dry; 10–20 cm tall, usually a few, rarely several fructifications united at the somewhat paler or whitish base, rarely growing singly; thickened toward or above the middle where 8–12 mm thick, attenuate toward the base, less so toward the apex which is obtuse, hollow and not compressed when fresh, becoming compressed when dry, golden yellow in color, without distinctive odor, the taste agreeable and distinctly not bitter.

Moist soil in open woods under the shade of ferns. Jenny brook, Yama farms, Napanoch, Ulster county. *Mr and Mrs J. A. Kingsbury* and *H. D. House,* August 9, 1922.

This is the plant commonly designated as Clavaria fusiformis Sowerby, in this State, and as such is not rare. According to English authorities the true C. fusiformis has a bitter taste and a more densely tufted habit and is canary-yellow in color.

Cordyceps agariciformis (Bolton) Seaver

In woods near Vernooy kill camp (Potterville), Ulster county, parasitic on old Scleroderma. *H. D. House,* August 8, 1922. **Cordyceps militaris** (L.) Link, parasitic on buried pupae, was also frequent in the same locality, and also at Yama farms, Napanoch.

Corticium investiens (Schw.) Bres.[2]

On dead limbs of maple, on ground in woods, near Oneida, Madison county. *H. D. House,* October 15, 1920.

Corticium tessulatum Cooke[2]

On decayed wood of hemlock, Osceola, Lewis county. *C. H. Peck.*

Corticium vellereum Ellis & Cragin[2]

On fallen branches of Populus tremuloides Michx., Albany, *H. D. House,* October 15, 1919. Collected by Doctor Peck at Westport (Corticium chlamydosporum Burt, in

[2] Determined by Dr E. A. Burt.

54th Ann. Rep't N. Y. State Mus. 154. 1901), and at Ottawa, Canada, by Macoun (no. 281, October 2, 1897).

Dicaeoma Acetosae (Schum.) Kuntze

On leaves of Rumex Acetosella L., Orient, Long Island. *Roy Latham,* October 15, 1919 (Puccinia Acetosae Korn.)

Dicaeoma asterum (Schw.) Arthur & Kern[1]

A common rust, recorded here for certain unusual hosts, namely, I on Aster acuminatus Michx. Boreas ponds, Essex county. *H. D. House,* July 20, 1922. II–III on Carex Houghtonii Torrey, Elizabethtown, Essex county. *Peck;* on Carex substricta (Kukenth.) Mackenzie, Woodville, Jefferson county. *H. D. House,* September 15, 1922.

Dicaeoma Eatoniae Arthur[1]

Perch lake, Jefferson county, on sheaths, culms and leaves of Sphenophollis pallens (Spreng.) Scribn. (Eatonia pennsylvanica Gray). *H. D. House,* June 27, 1922. The aecial stage occurs on Ranunculus abortivus L.

Dicaeoma Clematidis (DC.) Arthur[1]

Aecial stage on Thalictrum canadense Mill. (T. polygamum Muhl.), Indian pass, Essex county. *H. D. House,* July 15, 1923. The telial stage was also collected here on old culms of Andropogon tenerum Vasey.

Dicaeoma McClatchianum (D. & H.) Arthur[1]

Long lake, Hamilton county, and Cascade lakes, Essex county, on Scirpus microcarpus Presl. (S. rubrotinctus Fernald). *H. D. House,* September 14 and 16, 1920. Previous collections of this rust, on the same host, in this State have been made only in the vicinity of Albany.

Dicaeoma Majanthae (Schum.) Arthur

The aecial stage frequent about Newcomb, Essex county, on leaves of Trillium erectum L., and Trillium undulatum Willd. (Aecidium Trillii Burrill), and also on leaves of Unifolium canadense (Desf.) Greene and Streptopus roseus Michx. *H. D. House,* July 2 and 4, 1923.

Dicaeoma orbicula (Peck & Clinton) Arthur[1]

On leaves of Nabalus albus (L.) Hook. Woodville, Jefferson county. *H. D. House,* June 6, 1923.

Dicaeoma Peckii (DeToni) Arthur[1]

Newcomb, Essex county, on Carex rostrata Stokes, *H. D. House,* August 10, 1921. The aecial stage occurs upon Oenothera biennis L., and more rarely upon Kneiffia perennis (L.) Pennell (Oenothera pumila L.). Pompey, Onondaga county. *House,* June 28, 1916.

Dicaeoma Violae (Schum.) Kuntze

At Newcomb, Essex county, this rather common rust has been collected upon Viola renifolia Gray, V. cucullata Ait., V. septentrionalis Greene, V. incognita Brainerd, V. pallens (Banks) Brainerd, and V. pubescens Ait.

Grandinia sulphurella (Peck) Burt, comb. nov.

Hydnum sulphurellum Peck, 31st Rep't N. Y. State Mus. 38. 1879.

On dead branches on the ground in woods, near Oneida. *H. D. House,* October 15, 1920.[2] The type of Doctor Peck's species was collected at Griffins, and the state herbarium also contains a collection from Ottawa, Canada. *Macoun 14,* September 30, 1902.

Gymnosporangium germinale (Schw.) Kern

I on Amelanchier Bartramiana (Tausch) Roem. (A. oligocarpa (Michx.) Roem.) Newcomb, Essex county. *H. D. House,* July 18, 1922.

Hymenochaete arida Karsten[2]

On dead twigs of Fraxinus nigra Marsh., Newcomb, Essex county. *H. D. House,* July 15–30, 1920.

Hymenochaete badio-ferruginea (Mont.) Lev.[2]

On dead branches, Speculator, Hamilton county. *H. D. House,* August 12, 1920. Indian lake, *Peck.*

Hymenochaete episphaeria (Schw.) Massee[2]

On decayed limbs on the ground in woods, near Oneida, Madison county. *H. D. House,* October 18, 1920.

Hymenochaete tenuis Peck[2]

On dead limbs of Tsuga canadensis (L.) Carr., near Oneida, Madison county. *H. D. House,* October 15, 1920. The type was collected by Doctor Peck at Edmonds ponds, Essex county, on Thuja occidentalis L.

Hypocrea latizonata Peck[3]

In addition to the type, collected by Doctor Peck at Greenbush, Rensselaer, the herbarium contains a collection, heretofore unnamed, made by Doctor Peck at Sand lake, on Cyathus striatus (Huds.) Hoffm.

Hypomyces aurantius (Pers.) Tul.[3]

Newcomb, Essex county, parasitic on Auricularia Auricula (L.) Underw. *H. D. House,* July 15–30, 1920.

Hysterium thujarum Cooke & Peck

Orient, Long Island, on Juniperus virginiana L. *Roy Latham,* January 10, 1923.

Kuehneola Uredinis (Link) Arthur[1]

Hastings, Oswego county, on leaves of Rubus hispidus L. *H. D. House,* September 15, 1922. Also collected, September 27, 1922, on Rubus sativus Bailey, at Panther lake, Oswego county.

Lachnea setosa (Nees) Gill.[3]

Near Oneida, Madison county, on decayed basswood log. *H. D. House,* September 23, 1922.

Leotia marcida Pers.

Woods near Vernooy kill camp (Potterville), Ulster county. *H. D. House,* August 8, 1922. The pileus only is of a bright green color in this species, the stipe being buffy or pale yellowish brown in color.

Macroplodia Sabina House, nom. nov.

Sphaeropsis Juniperi Peck, 39th Rep't N. Y. State Mus. 45. 1889. Not Desm.

Macroplodia Juniperi Kuntze.

On dead bark of Juniperus virginiana L., Orient, Long Island. *Latham.* West Albany. *Peck.*

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[3] Determined by Dr F. J. Seaver.

Melampsora americana Arthur[1]

Newcomb, Essex county, on leaves of Salix nigra Marsh. *H. D. House,* August 10, 1921.

Melampsoropsis abietina (A. & S.) Arthur[1]

Newcomb, Tahawas, Calamity pond, Adirondack lodge, and other localities in Essex county, apparently common, on the under surface of leaves of Ledum groenlandicum Oeder. *H. D. House,* June 26–30, 1923. The aecial stage is Peridermium abietinum (A. & S.) Thum. on leaves of Picea rubens, as demonstrated by Fraser in America, and by Klebahn in Europe for other species of Picea.

Melampsoropsis Cassandrae (Peck & Clinton) Arthur[1]

On leaves of Chamaedaphne calyculata (L.) Moench, in bog at base of Moxon mountain, near North Creek, Warren county. *H. D. House,* June 26, 1923. Also on the same host at Newcomb, Calamity pond, and other localities in Essex county, always in association with Picea mariana (Mill.) B. S. P., upon which the aecial stage, Peridermium consimile A. & K. occurs. There is also in the herbarium a specimen of the aecial stage from Junius swamp, Seneca county, collected by *E. J. Durand,* July 1905.

Empusa americana Thaxter

Orient, Long Island, on blow flies (*Calliphora vomitoria*). *Roy Latham,* August 20, 1920 and October 15, 1919.

Melampsoropsis Chiogenes (Dietel) Arthur

On the under sides of leaves of Chiogenes hispidula (L.) A. Gray, Newcomb, Essex county, *H. D. House,* July 18, 1922 and July 2, 1923. Apparently not rare, but easily overlooked, as it was also found at Tahawas, Calamity pond, Indian pass and Chapel pond, all in Essex county, and near Long lake in Hamilton county. The aecial stage is not definitely known, but is probably some unrecognized Peridermium upon the leaves or cones of spruce, although balsam fir occurs in the same localities.

Melampsoropsis ledicola (Peck) Arthur[1]

On the upper surface of leaves of Ledum groenlandicum Oeder, bog at base of Moxon mountain near North Creek,

Warren county, *H. D. House,* July 25, 1923. On the same host, summit of Mount McIntyre, July 13, 1923. At the last named locality dwarfed examples of Abies balsamea and Picea mariana were the only associated conifers.

Melampsorella elatina (A. & S.) Arthur

II–III, on leaves of Stellaria borealis Bigelow (Alsine borealis Britton), Newcomb, Essex county. *H. D. House,* July 22, 1922. The heavily infested clusters (Witches broom) caused by the aecial stage of this rust on the balsam fir (Abies balsamea) are very common about Newcomb, and their abundance suggested a careful search for the alternate stage, known to occur upon species of Alsinaceae. Stellaria borealis was noted to be abundant especially in low places where the balsam fir was often infected, and in July the leaves of the Stellaria were found to be abundantly infected with the telial stage in several places about Newcomb. No infection was found upon Cerastium vulgatum L. The sori on the leaves of Stellaria are very inconspicuous and easily overlooked.

Merulius ochraceus Lloyd[2]

On decayed wood of Betula lutea Michx.f., North Elba, Essex county. *Peck.* Indian pass. *Peck.*

Merulius corium Fries[2]

On dead limbs of Salix nigra Marsh. Albany. *H. D. House,* December 28, 1919. Burt (Ann. Mo. Bot. Gard. 4 : 323. 1917) cites a collection from White Plains, by Underwood.

Micropuccinia conglomerata (K. & S.) Arthur & Kern[1]

In 1920 and 1921 this rare rust was collected in abundance upon the leaves of Petasites palmata (L.) Gray, near Newcomb. On July 20, 1922, it was also found upon the same host at Boreas ponds about 20 miles east of Newcomb.

Micropuccinia porphyrogenita (M. A. Curt.) Arthur & Jackson

Newcomb and Boreas ponds, Essex county, on leaves of Cornus canadensis L. *H. D. House,* July 18 and 20, 1922.

Micropuccinia mesomajalis (B. & C.) Arthur & Jackson

On living leaves of Clintonia borealis (Ait.) Raf., northern end of Indian pass, Essex county, about 2400 feet altitude. *H. D. House,* July 15, 1923.

Micropuccinia recedens (Sydow) Arthur & Jackson

On living leaves of Senecio aureus L., Williamsbridge, New York City. *Percy Wilson 303,* June 2, 1916. Arkville, Delaware county. *Percy Wilson 117,* July 25, 1915. This rust is said to be correlated with Dicaeoma Eriophori (Thum.) Kuntze, which has Senecio aureus as its aecial host, and species of Eriophorum as telial hosts.

Monochaetia Syringae Oudemans

On bark of Syringa vulgaris L., Yates, Orleans county. *Dr C. E. Fairman,* November 1923.

NEMANIA S. F. Gray. Nat. Arr. Br. Pl. 1: 516. 1821

Ustulina Tul. Sel. Fung. Carp. 2: 23. 1863 — Sacc. Syll. Fung. 1: 350. 1882.

The first species (of the twenty-one) enumerated by Gray is Nemania deusta. It is also the first of the species listed which is accompanied by a plate citation. Taken as a whole the generic name Nemania has no more congeneric alignment than Gray's genera Crepidopus, Micromphale and Prunulus, which have recently been resurrected in the Agaricaceae. In considering these generic names of Gray perhaps no safer method can be followed, where they are to be taken up because of their priority, than to adopt the first species enumerated as the type.

Nemania maxima (Haller) comb. nov.

Sphaeria maxima Haller. Nom. Hist. Pl. Helvet. 1769 — Sow. Engl. Fung. *t. 338.* 1801

Sphaeria deusta Hoffm. Veg. Crypt. 1: 3. t. 1. f. 2. 1787 — Pers. Syn. 16. 1801.

Sphaeria versipellis Tode, Fungi Meckl. 2: 55. 1791

Hypoxylon ustulatum Bull. Champ. 1: 176. t. 478. f. 1. 1791

Hypoxylon deustum Grev. Crypt. Fl. 4: t. 324. f. 2. 1825

Nemania deusta S. F. Gray, 1. c.

Ustulina vulgaris Tul. Sel. Fung. Carp. 2: 23. t. III. f. 1–6. 1863

Ustulina maxima Schroeter, in Cohn, Kryptofl. Schles. III, 2: 465. 1897.

Frequent throughout New York State on a variety of hosts, but usually on Quercus or Betula.

Nigredo Lilii (G. W. Clinton) Arthur

On seedling leaves of Lilium canadense L., Woodville, Jefferson county. *H. D. House,* June 6, 1923.

Nigredo Scirpi (Cast.) Arthur[1]

Aecial stage on Sium cicutaefolium Schrank, Woodville, Jefferson county. *H. D. House,* June 24, 1921. Telial stage collected at the same locality, September 10, 1921 and September 15, 1922, on Scirpus validus Vahl.

Nigredo seditiosa (Kern) Arthur

On Aristida tuberculosa Nutt., Laurel, Long Island. *Roy Latham,* September 15, 1915 and April 20, 1923.

Nigredo Silphii (Burrill) Arthur[1]

Telial stage on Juncus tenuis Willd. along the Mount Marcy trail at 3500 feet altitude, Essex county. *H. D. House,* August 5, 1921.

NUMULARIOLA gen. nom. nov.

Nummularia Tul. Sel. Fung. Carp. 2: 42. 1861 — Sacc. Syll. Fung. 1: 396. 1882. Not Nummularia (Riv.) Rupp. Fl. Jen. 18. 1745 — Numularia Gilib. Fl. Lithuan. 1: 29. 1781 — S. F. Gray, Nat. Arr. Br. Pl. 2: 300. 1821

In many of the early European treatments of the flowering plants, the Moneywort was known as Nummularia or Numularia, having the same derivation as the fungus genus Nummularia Tulasne. Numularia of Gilbert and S. F. Gray is now usually merged into Lysimachia, but still recognized as of subgeneric rank, was not an invalid name when proposed, and would still be the valid name if that section of Lysimachia should be restored to generic rank.

Numulariola atropunctata (Schw.) comb. nov. (Sphaeria atropunctata Schw., Diatrype atropunctata Berk., Hypoxylon atropunctatum Cooke; Anthostoma atropunctata Sacc.) Found chiefly on dead limbs of Fagus and Quercus in this State.

Numulariola discreta (Schw.) comb. nov. (Sphaeria discreta Schw., Nummularia discreta Tul.) Frequent on dead branches of Malus, Aronia, Amelanchier etc., and on the apple tree regarded as the cause of the "apple blister canker" disease.

Numulariola nummularia (Bull.) comb. nov. (Hypoxylon nummularium Bull. Champ. de Fr. t. 468. f. 4. 1789; Sphaeria Clypeus Schw.; Nummularia Bulliardi Tul.) Frequent on dead limbs of oak, especially Quercus alba L., and occasionally on Fagus grandifolia and other species.

Numulariola repanda (Fries) comb. nov. (Sphaeria repanda Hypoxylon repandum Fr., Nummularia repanda Nitsche, Nummularia pezizoides E. & E.) On dead branches and limbs of Sorbus americana Marsh. North Elba. *C. H. Peck.*

Patellina caesia Elliott & Stansfield

On cone-scales of cultivated Pinus Laricio Poir. lying on the ground and buried by herbage, Ridgeway, Orleans county. *Dr C. E. Fairman,* November 1923.

Peniophora mutata (Peck) Bres.[2]

On decayed limbs of basswood, on ground in woods, near Oneida, Madison county. *H. D. House,* October 20, 1920. Also collected near Albany in 1913 and 1915. Doctor Peck's type was collected at Sevey.

Peniophora velutina (DC.) Cooke[2]

On dead limbs of Salix nigra Marsh., Albany. *H. D. House,* December 21, 1919. The same tree yielded collections of the following:

Peniophora incarnata (Pers.) Cooke
Peniophora cinerea (Fr.) Cooke
Corticium confluens Fr.
Corticium effuscatum C. & E.
Corticium salicinum Fr.
Merulius corium Fr.

Peziza clypeata Schw.[3]

On decayed and water-soaked basswood log in deep woods near Oneida, Madison county. *H. D. House,* September 23, 1922. This was described by Peck (N. Y. State Mus. Bul. 2 : 30. pl. 2. f. 4–6. 1887) as P. orbicularis. A complete account of the species is given by Seaver (Mycologia 8 : 237. pl. 191. 1916).

Phallus rubicundus Bosc.

Greenport, Long Island. *Roy Latham,* March 13, 1921.

Phorcys Xanthoxyli (Peck) House, comb. nov.

Massariella Xanthoxyli Peck. 46th Rep't N. Y. State Mus. 36. 1893

On dead branches of Xanthoxylum americanum L., Mechanicville. *C. H. Peck.* As indicated by Lindau (Engler & Prantl. Nat. Pflanzenfam. 1 : 444. 1897), the generic name Phorcys Niessl. has priority over Massariella Speg. Phorcys

bufonia (Berk. & Br.) Schroter, on Quercus; and P. Tiliae (Curr.) Schroter (Massariella Curreyi (Tul.) Sacc.) on Tilia, are two additional species of this genus found in New York.

Phragmidium americanum Dietel[1]

Newcomb, Essex county, on Rosa blanda Ait. *H. D. House,* August 3, 1921.

Phyllachora Dalibardae (Peck) Sacc.

Newcomb, Essex county, on leaves of Dalibarda repens L. *H. D. House,* July 22, 1922. Present only on the leaves of the preceding season's growth.

Phyllachora Wittrockii (Erikss.) Sacc.

Newcomb, Essex county, on the terminal shoots of Linnaea borealis L., var. americana (Forbes) Rehder. *H. D. House,* July 18, 1922. Very common upon this host in nearly all of the deep swamps about Newcomb during this season. In open places the host seem to be rarely infected by it. The parasitic nature of the fungus causes considerable damage to the host in some places.

Physalacria inflata (Schw.) Peck

Newcomb, Essex county, on decayed log of Acer saccharum Marsh. *H. D. House,* August 3, 1921. Osceola, Lewis county, September 20–22, 1922.

Peck bases the genus Physalacria on Leotia inflata Schw. (Bul. Torrey Bot. Club 9 : 2. pl. IX, figs. 1–5. May 1882). Mr Louis C. C. Krieger (Maryland Acad. Sci. Bul. 3 : 7–8. 1923), after a careful study of the characters of this species, decides that it really belongs to the Agaricaceae, where its nearest relatives are Gloiocephala Massee, and Eomycenella Atkinson. Krieger changes the generic name to Eoagaricus (E. inflatus (Schw.) Krieger, l. c. p. 8), an entirely unnecessary procedure since Leotia inflata Schw. is the type of the genus Physolacria Peck. If the transfer of the species to the Agaricaceae is required, the generic name of which it is the type goes with it, unless there is already in the Agaricaceae a prior generic name with which it is synonymous. There is neither precedent (in modern literature at least) nor rule requiring or permitting a change of generic name under such circumstances.

Poria barbaeformis (B. & C.) Sacc.[4]

Ausable Chasm. *C. G. Pringle 1383,* October 19, 1880.

Poria corticola (Fr.) Cooke[4]

Harrisville, Lewis county, on Acer. *C. H. Peck.* July.

Poria lenis (Karst.) Bres.[4]

Mechanicville, on pine. *C. H. Peck,* October.

Poria nigrescens Bres.[4]

Floodwood, Franklin county, on decayed wood. *C. H. Peck,* August. Fine, St Lawrence county, on Betula lutea Michx. *C. H. Peck,* August.

Poria mucida Pers.[4]

Albany, on decayed log of Betula lutea. *H. D. House,* October 15, 1919 and September 4, 1922.

Poria laevigata Fr.[4]

Newcomb, Essex county, on dead trunk of Prunus serotina Ehrh. *H. D. House,* July 24, 1920.

Poria papyracea Schw.

Newcomb, Essex county, on dead branches and twigs of Thuja occidentalis L. *H. D. House,* August 2, 1921. Determined by Dr L. O. Overholts. Spores elongate, punctate, 10–15 x 3–5 μ; cystidia none; basidia 9–11 μ in diameter.

Poria vitillina (Schw.) Sacc.[4]

Albany, on stump of white pine. *H. D. House,* September 24, 1919.

Porothelium subtile (Schrad.) Fr.[4]

North Elba, Essex county, on spruce. *C. H. Peck.* September.

Prunulus alcaliniformis Murrill (N. Am. Fl. 9 : 331. 1916.)

Among fallen needles under coniferous trees, North Elba. *C. H. Peck,* September 7, 1910. This was described by Doctor Peck in his unpublished notes (30 : 74) under a manuscript name, which was never published. Evidently Doctor Peck considered it too closely related to Mycena subplicosa Karsten, with which he compares it, and from which he says it differs only in its viscid stem and its somewhat closer lamellae. The stem, however, is not conspicuously viscid, as Peck notes, and otherwise his diagnosis of

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[4] Determined by Dr James R. Weir.

the North Elba specimens agrees with Murrill's description of Prunulus alcaliniformis. Apparently Murrill's species should be carefully compared with authentic European material of Mycena subplicosa Karsten.

Pucciniastrum Agrimoniae (Schw.) Thum.

Albany, on leaves of Agrimonia parviflora Ait. *H. D. House,* October 14, 1922.

Pucciniastrum americanum (Farlow) Arthur[1]

Collected on Rubus strigosus Michx. at the following localities: Peterboro, Madison county, July 3, 1921; Newcomb, Essex county, August 4, 1921; Tahawas, Essex county, July 14, 1922; Osceola, Lewis county, September 20, 1922.

Rosellinia ligniaria (Grev.) Fckl.

Newcomb, Essex county, on dead bark of Fagus grandifolia Ehrh. *H. D. House,* June 6–10, 1921. This has also been collected at Alcove, Albany county, on Sambucus, by *Shear* (N. Y. Fungi no. 361), and in Orleans county by *Doctor Fairman.*

Sebacina calcea (Pers.) Bres.[2]

On dead limbs of Tsuga canadensis (L.) Carr., near Oneida, Madison county. *H. D. House,* October 15, 1920. Doctor Peck collected it on spruce, at Hague, Warren county, and at North Elba, Essex county. Pringle's no. 1008 (1875) from Vermont, and a collection from Ottawa, Canada, *Macoun,* 1903, also belong here.

Septocylindrium melleum Elliott & Stansfield

On cones of Pinus sp. (cultivated), Lyndonville, Orleans county. *Dr C. E. Fairman,* October 25, 1915.

Septocylindrium strobilinum (Sacc.) Fairman

(Cylindrium strobilinum Sacc., S. leucum Elliott & Stansfield)

On buried cones of Pinus Laricio Poir. (cultivated), Ridgeway, Orleans county. *Dr C. E. Fairman,* November 1923.

Sporoschisma mirabile B. & Br.

On beech and maple firewood, Lyndonville, Orleans county. *Dr C. E. Fairman,* September 19, 1923.

Steccherinum adustum (Schw.) Banker

On decayed limb on the ground in woods, Vernooy kill camp (Potterville), Ulster county. *H. D. House,* August 8, 1922. **Steccherinum septentrionale** (Fries) Banker, was also collected in the same locality by *Dr W. A. Murrill* and *J. A. Kingsbury,* on August 10, 1922, and a portion of the several large imbricated pilei preserved for the state herbarium.

STRICKERIA Korb. Parerga 400. 1865

Teichospora Fckl. Symb. Myc. 100. 1869

The priority of Strickeria Korb. over Teichospora Fckl. has already been indicated by Lindau (l. c. p. 416) as well, as by Kuntze. The following species are known to occur in New York:

Strickeria Chevalierii (Karsten) comb. nov. (Teichospora Chevalierii Karsten), see page 72.

Strickeria elliptica (Peck) comb. nov. (Teichospora elliptica Peck).

Strickeria interstitialis (C. & P.) Kuntze

Strickeria obducens (Fr.) Winter

Strickeria phellogena (B. & C.) Kuntze

Strickeria praeclara (Rehm) comb. nov. (Teichospora praeclara Rehm, Ann. Myc. 4: 336. 1906), on bark of Ostrya virginiana, Lyndonville. *Dr C. E. Fairman.*

Strickeria trimorpha (Atkinson) comb. nov. (Teichospora trimorpha Atkinson), on bark and dead branches of Populus, Ithaca. *Atkinson.*

Telimena Elymi Orton

On leaves and culms of Elymus virginicus L. North Bay, Oneida county. *H. D. House,* October 13, 1915. Determined by Doctor Orton.

Trematosphaeria caryophaga (Schw.) Sacc.

Sphaeria caryophaga Schw. Syn. Am. Bor. No. 1594 Trans. Am. Phil. Soc. 4: 1834 — Sacc. Syll. 2: 412. 1883 — Cooke, Grevillea 18: 60. 1890
Sphaeria nuclearia DeNot. Micr. Ital. 9: 462. f. 4. 1857
Hypoxylon nucitena B. & C. N. Am. Fungi no. 844.
Melanoma ? nucitena Sacc. Syll. Fung. 2: 103. 1883
Trematosphaeria nuclearia (DeNot.) Sacc., Syll. 2: 121. 1883

On old or partially decayed nuts of Hicoria ovata. Albany. *H. D. House 165,* May 14, 1924. Vaughns, Washington county. *Burnham,* 1913. Orient, Long Island. *Latham,* May 1, 1923.

Tremella vesicaria Bull.

Figure 1

On ground in open woods among fallen decayed leaves and growing grass. Vernooy kill camp (Potterville), Ulster county. *H. D. House,* August 9, 1922.

The varying forms which this plant assumes seem to have been the cause of much confusion. Farlow, Overholts, Lloyd and Burt have described it under various names. The first collection made at Potterville on August 9th, was an exact match for Lloyd's Tremella sparassoidea.[5] Upon my request Bertha Empt of Vernooy kill camp sent me later in the month (August 30th) from the same spot, an additional collection, which matches Lloyd's description of Tremella vesicaria,[6] and which was photographed and is here illustrated.

The history of the fungus in America is anything but clear. Berkeley[7] first described it briefly as Corticium tremellinum var. reticulatum. I believe that the expression "reticulated below" as used by Berkeley in this diagnosis has been misunderstood by Lloyd, who says that the plant is not reticulated below. The expression used by Berkeley evidently refers to the common feature of the confluent lobes, which in some plants is especially noticeable toward the base, and which gives them a sponge-like appearance. In other plants, usually small ones, the lobes are more or less free and broadly clavate. In all specimens the lobes are hollow above, but somewhat spongy within toward the base. Farlow[8] took up Berkeley's name and called the plant Tremella reticulata.

In the state herbarium are collections made by Doctor Peck[9] at three or four widely separated localities, which he referred to Tremella vesicaria Bulliard. Doctor Peck later changed his identification of these plants to Tremella fuciformis Berk. As has been lately noted by Burt,[10] Tremella fuciformis is a smaller and more southern species.

Lloyd, in 1908,[11] described what is apparently the same thing under the name of Tremella clavarioides. This form is well represented by at least three collections in the state herbarium, which must have been here at the time of Lloyd's visits. They are from Albany, *Peck;* Bethlehem, *C. C. Nichols;* and

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[5] Lloyd. Tremella sparassoidea. Myc. Writ. 6: (Myc. Notes 61. page 894. pl. 135. f. 1562.) 1920.

[6] Lloyd. Tremella vesicaria Myc. Writ. 6: (Myc. Notes, p. 871. f. 1486.) 1919.

[7] Berkeley. Corticium tremellinum var. reticulatum. Grevillea I: 180. 1873.

[8] Farlow. Rhodora 10: 9. 1908.

[9] Peck. Tremella vesicaria Bull. 28th Rep't N. Y. State Mus. 53. 1879.

[10] Burt. Tremella reticulata. Ann. Missouri Bot. Gard. 8: 364. 1921.

[11] Lloyd. Tremella clavarioides. Myc. Writ. 3: (Myc. Notes, Old Species Series 1: 10. text fig. 224.) July 1908.

Oneida, *H. A. Warne.* Lloyd states,[12] however, "nor did I find it in Peck's Museum." This doubtless refers to the state herbarium in Doctor Peck's charge, since it is unknown that Dr Peck ever possessed a museum.

Tremella sparassoidea is described by Lloyd[5] from Minnesota, and also from a collection made in Pennsylvania by Overholts.[13] This is an extreme form of the species with numerous spinelike outgrowths on the tops of the hollow, clavate branches. Fresh plants at Vernooy kill camp showed this condition beautifully. The next day, following a heavy rain, and also on plants 2 or 3 days old, these spinelike processes had disappeared entirely in some cases, and to a large extent in all of the other older plants examined which had passed through the rainstorm or were rather old.

From these observations I am inclined to believe that Tremella clavarioides, T. sparassoidea and T. reticulata all represent forms or conditions of the same species, which is the same conclusion reached by Doctor Burt. Whether Tremella vesicaria Bulliard, is the correct name for our plant I do not know. Lloyd says that Bulliard's figure is not our plant. I am disposed to refer it there until our plant has been compared with European specimens. Lloyd[6] also ventures the opinion that Guepinia helvelloides Schw. is the same species and under the pseudonym "McGinty" makes the new combination Tremella helvelloides.

Uredinopsis mirabilis (Peck) Magnus

II–III on Onoclea sensibilis L., Newcomb, Essex county. *H. D. House,* July 22, 1922. The aecial stage, Peridermium balsameum Peck, on the leaves of Abies balsamea is common in this region and is to be found in nearly every thicket and swamp where the hosts are found in association.

Uredinopsis Osmundae Magnus

II–III on Osmunda Claytoniana L., Newcomb, Essex county. *H. D. House,* July 22, 1922. Osceola, Lewis county, and Alder Creek, Oneida county, on Osmunda regalis L.

Urocystis Waldsteiniae Peck

Woods south of New Salem, Albany county, on leaves of Waldsteinia fragarioides (Michx.) Tratt. *H. D. House,* May 27, 1922.

Ustilago residua Clinton

On Danthonia spicata (L.) Beauv., Elk park, Catskill mountains. *Dr L. H. Pennington,* June 25, 1914.

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[12] Lloyd. Mycological Notes 62, page 920, pl. 145. f. 1646. 1920.

[13] Overholts. Tremella sparassoidea. Mycologia 12: 141. pl. 10. fig. 3, 1920.

Figure 1 TREMELLA VESICARIA Bulliard
From specimens collected at Vernooy kill camp, Potterville, Ulster county, August 9, 1922

NEW OR NOTEWORTHY SPECIES OF FUNGI, IV

BY

JOHN DEARNESS AND HOMER D. HOUSE

Among the species here noted, the following are described as new species or varieties:[1]

Acrospermum cuneolum
Belonidium Spiraeae
Cenangium griseum
Cylindrosporium fraxinicolum
Dendrophoma Azaleae
Diplosporium flavidum
Diplosporium Polypori
Dothidella caricina
Gnonomia setacea var. Caryae
Helicia buccina
Helminthosporium naviculatum
Helminthosporium Phomatae
Leptosphaeria borealis var. Populi
Leptostroma Allii
Leptostromella Angelicae
Leptostromella Mali
Leptothyrella Aceris
Lophodermium Oxycocci var. hypophyllum
Macroplodia Clematidis
Macroplodia juglandicola
Micropeltis Viburni
Melanconiella subviridis
Melanconis subviridis
Myxosporium Liriodendri
Nectria episphaeria var. minor
Ombrophila setulata
Phyllachora Melicae
Placosphaeria Baccharidis
Pleospora herbarum var. Triglochinis
Pseudographis Phragmitis
Rhabdospora Polygoni
Scopaphoma Corioli
Septomyxa grisea
Sphaerographium niveum
Tympanis Cephalanthi

The following species of fungi, have not, so far as we are able to ascertain, been previously reported from New York State:

Acrothecium melanoplus (Schw.) Sacc.
Amphisphaeria applanata (Fr.) Ces. & DeNot.
Anthostoma amplispora (Cke.) E. & E.
Beloniella brevipila (R. & D.) Dearn. & House
Botrydiplodia Celastri (Cke.) Sacc.
Cercospora avicularis Winter
Cercospora omphacodes E. & E.
Ciboria firma (Pers.) Fckl.

[1] Unless otherwise stated, the types of new species herein described, and the specimens otherwise reported upon, are in the herbarium of the New York State Museum.

Dendrophoma Syringae Dearn.
Didymosphaeria Linderae Sacc.
Durella minutissima Rehm.
Exoascus Farlowii (Sadeb.) Sacc.
Heterosphaeria Linariae (Rabh.) Rehm
Leptostroma Abietis Rostr.
Lophodermium Abietis Rostr.
Lophodermium tumidum (Fr.) Rehm
Macrophoma dryina (B. & C.) Berl. & Vogl.
Macroplodia simillima (Peck) Dearn. & House
Macrosporium Martindalei Ell. & Mart.
Melanconium parvulum Dearn. & Barth.
Metasphaeria microecia E. & E.
Metasphaeria subcutanea (C. & E.) Dearn. & House
Microdiplodia Linderae (E. & E.) Dearn. & House
Ophiobolus filisporus (C. & E.) Sacc.
Otthiella staphylina (E. & E.) Dearn. & House
Patellaria nigrovirens Sacc. & Ell.
Phacidium Populi Lasch
Phoma glandicola Desm.
Phoma nervisequa Sacc.
Phyllachora Oryzopsidis Theiss. & Sydow
Pleospora scabra Mont.
Pleospora vagans Niessl.
Pyrenopeziza compressula Rehm
Ramularia Chamaenerii Rostr.
Septoria alnifolia E. & E.
Septoria Commonsii E. & E.
Septoria Sii Rob. & Desm.
Taphrina Johansonii Sadeb.
Teichospora Chevalierii Karst.
Tubercularia Ailanthi Cke.

In addition the following species, collected during 1917–18, in Panama, by Ellsworth P. Killip, are either described or briefly noted:

Asterina Killipii, sp. nov.
Glomerella cingulata (Stonem.) Spaulding & Von Schrenk
Guignardia Pleurothallis, sp. nov.
Leptostromella Andropogonis, sp. nov.
Leptostromella septorioides Sacc. & Roum.
Macrophoma Pernettyae, sp. nov.
Meliola Cookeana Sacc.
Pestalozzia Gaultheriae, sp. nov.

MYXOGASTRALES

Didymium melanospermum (Pers.) Macbr. var. **minus** (Lister) Dearness & House, comb. nov.

Didymium minus Lister. Jour. Cinc. Soc. Nat. Hist. 61. t. XII, f. 39. 1894

Newcomb, Essex county, on Chiogenes hispidula (L.) Gray, and other low forms of vegetation on the ground in swamps. *H. D. House,* August 10, 1921, September 1922.

Badhamia utricularis (Bull.) Berk.

Averyville marsh, North Elba, Essex county. *D. M. White,* on Carex strictior Dewey, July 28, 1917.

Dictydiaethalium plumbeum (Schum.) Rost.

On dead branches of Robinia pseudoacacia L. Albany. *H. D. House,* November 17, 1919.

Leocarpus fragilis (Dickson) Rost.

Newcomb, Essex county, attached to various kinds of vegetation on ground in swamps, especially on Vaccinium Oxycoccus L. *H. D. House,* July 25, 1920.

PHYCOMYCETES

Albugo Tragopogonis (DC.) S. F. Gray

Tahawas, Essex county, on leaves of Cirsium muticum L. *H. D. House,* July 14, 1922.

ASCOMYCETES

Exoascus Farlowii (Sadeb.) Sacc.

Newcomb, Essex county, on immature fruit of Prunus serotina Ehrh. *H. D. House,* June 7, 1921. On the same host, Fourth lake, Herkimer county, August 8, 1919.

Taphrina Johansonii Sadeb.

On pistillate aments of Populus alba L., Woodville, Jefferson county. *H. D. House,* June 6, 1923. Some of the asci in the Woodville collection have a rather long immersed portion (one was measured 63 μ) and there is some question owing to the inability to consult certain literature, whether this should not be referred to Taphrina rhizophora Johans.

Vibrissea truncorum (A. & S.) Fries

Avalanche lake, Essex county, on spruce log partially immersed and wholly water soaked. *H. D. House,* June 30, 1923. The variety albipes Peck, seems to have merely a shorter, whiter stem than the typical form of the species, and was collected at Newcomb, July 5, 1923.

Melachroia xanthomela (Pers.) Boud.

Newcomb, Essex county, on much decayed log in woods. *H. D. House,* September 30, 1922.

Ciboria firma (Pers.) Fckl.

On chips of Betula lutea Michx. f., in ravine at the southern base of Peaked mountain, Washington county. *S. H. Burnham,* June 9, 1918. Determined by Dr F. J. Seaver.

Trichopeziza myricacea (Peck) Sacc.

On dead twigs of Myrica Gale L., Newcomb, Essex county. *H. D. House*, June 22, 1923. The type of this species was collected by Doctor Peck on the same host at North Elba. The Newcomb material contains also some Metasphaeria myricae Peck, the only other collection in this State being the type specimens collected by Peck at Caroga. On the Newcomb material is also Diaporthe phomaspora (C. & E.) E. & E., which has also been once collected in this State by Doctor Peck at North Elba, and reported as D. Wibbei.[1]

Pezizella Lathyri (Desm.) Shear & Dodge[2]

The conidial stage, Hainesia Lathyri (Desm.) von Hohn. on living leaves of Steironema ciliatum (L.) Raf., Sylvan Beach, Oneida county. *C. H. Peck.* The pycnidial stage, Sclerotiopsis concava (Desm.) Shear & Dodge (Leptothyrium macrothecium Fckl.) on fallen leaves of Quercus ilicifolia Wang., Karner, Albany county. *C. H. Peck.* (The exact date of Doctor Peck's collections of this material is unknown.)

Ombrophila setulata Dearness & House, sp. nov.

Erumpent, .3–1.5 mm, horny when dry, gelatinous when moist, solitary, scattered, exceptionally two or three in a cluster, substipitate or merely contracted to a narrow base; exciple leather-brown, involute when dry, prosenchymatous, the cells contracted into fascicles at the margin, terminating into acuminate, brown, four-six-septate setae, 60–100 μ long and 10–12 μ thick at the base; disc gray, plane when moist; asci cylindric-clavate, obtuse, tips blue with iodine, 95–130 x 12μ; paraphyses linear, hyaline, somewhat enlarged at the tips; sporidia hyaline, continuous, 12–18 μ long, mostly over 16 x 7 μ, many of them with a nucleus filling each end and leaving a granulated zone that simulates a septum.

Newcomb, Essex county, on dead twigs of Acer spicatum Lam. *H. D. House*, June 8, 1922.

Belonidium Spiraeae Dearness & House, sp. nov.

Ascomata gregarious, dark brown or black, 1–1.25 mm broad at the top when mature, .75 mm high, erumpent, closed globose at first, then turbinate, margin remaining incurved, becoming stellate or lacerate, ridged-rugose; cells of the ectothecium brown, elongate, many of them about 15 x 3 μ. Asci cylindric or somewhat larger toward the top, not blue with iodine, 60–75 x 7–8 μ; paraphyses

[1] New York State Mus. Bul. 197: 28. 1918.
[2] Mycologia 13: 135–70. pl. 8–10. 1921.

filiform, abundant. Sporidia hyaline, almost linear, wider above, three-septate, 15–27 x 2.5–2.75 μ.

On dead stems of Spiraea latifolia Borkh. Indian pass, Essex county, 3000 feet altitude. *H. D. House,* July 15, 1923 (type). Newcomb, Essex county, June 5, 1922 and July 1, 1923. On dead stems of Opulaster opulifolius (L.) Kuntze, London, Ontario. *J. Dearness.*

Belonidium Macounii Dearness, on Spiraea Menziesii, has an entire margin, and larger asci and sporidia. As seen under the lens the ascomata of the two species appear quite different.

Beloniella brevipila (Rob. & Desm.) Rehm

(Trichopeziza brevipila Sacc.; Pirottaea brevipila Boud.)

Newcomb, Essex county, on dead stems of Solidago humulis Pursh (S. uliginosa Nutt.). *H. D. House,* June 9, 1922. Some of the asci are two-spored, others four-spored; sporidia one to eight-septate and 25–36 x 3 μ.

Pyrenopeziza compressula Rehm

Sandlake, Rensselaer county, on dead stems of Thalictrum canadense Mill. (T. polygamum Muhl.). *C. H. Peck.* A portion of this material was sent to Saccardo a few years ago as no. 88, and determined by him as Pyrenopeziza Thalictri (Peck) Sacc. Reexamination of the portion retained here shows that it has spores mostly 6–7 x 2–3 μ, and does not seem to conform to Saccardo's determination.[3] The host was erroneously stated to be Thalictrum purpurascens.

Pyrenopeziza subatra (Cooke & Peck) Sacc.

Woodville, Jefferson county, on dead stems of Decodon verticillata (L.) Ell. *H. D. House,* June 21, 1922.

Durella minutissima Rehm

Albany, on decorticated and dead branches of Prunus serotina Ehrh. *H. D. House,* December 28, 1919.

Patellaria nigrovirens Sacc. & Ell.

Albany, on decorticated and dead stems of Cornus stolonifera Michx. *H. D. House,* April 3, 1923. Most of the apothecia

[3] New York State Mus. Bul. 197: 49. 1918.

here would be taken for Patellina, but a few mature ones show it to be a Patellaria, and from the description it is referred to P. nigrovirens. The same material also contains Valsa cornina, and a form of Hysterographium Mori (Schw.) Rehm.

Cenangium griseum Dearness & House, sp. nov.

Gregarious, erumpent, sessile, ½–2 mm, clothed externally with a pale gray furfuraceous covering; disc pale brown, concave; asci cylindrical stipitate, not blue with iodine, p. sp. 85–90 x 8–12 μ; paraphyses longer than the asci, tips thickened, agglutinated, forming an epithecium; sporidia 8, hyaline, uniseriate, elliptic, very minutely asperate, 10–15 μ, mostly about 12 x 7–10 μ.

On dead branches of Acer spicatum Lam., Newcomb, Essex county. *H. D. House,* June 6, 1922. Cenangium bicolor (Ell.) Sacc., also on Acer, differs in having a darker disc and much narrower spores.

Godronia Cephalanthi (Schw.) Dearness & House, comb. nov.

Peziza Cephalanthi Schw. Syn. Fung. Carol. n. 1256. 1822
Cenangium Cephalanthi Sacc. Syll. 8: 571. 1899 — ? Fries, Syst. Myc. 2: 188. 1822

Saccardo in compiling Cenangium Cephalanthi had only the incomplete account of Fries. The study of a collection in mature fruit enables us to add the following characters:

Asci clavate, 63–75 x 8–10 μ; paraphyses linear, longer than the asci, concolorous at the tips and somewhat thickened; sporidia linear, narrowly clavate, hyaline, five to eight-septate, 30–65 x 3 μ.

On the character of the mature fruit this is referred by us to Godronia. The brief description by Fries applies perfectly as far as it goes, to the material here cited. The plants are erumpent and have a thin, brown, short-celled perithecium which in mature, dry specimens is as stated by Fries, "lacero involuto." In the bright colored disc, branched paraphyses and filiform sporidia, some of the immersed units suggest Naemacyclus. It is left, however, in the dermataceae where Fries and Doctor Peck classified it, although it lacks the usual firmness of that order.

Karner, Albany county. *C. H. Peck.* West Albany. *Peck.* Greenbush, Rensselaer county. *C. H. Peck,* all on Cephalanthus occidentalis L. There is also a specimen from Alabama collected by Peters in the collection received by Doctor Peck from M. A. Curtis.

Godronia Nemopanthis (Peck) Sacc.

On dead branches of Nemopanthus mucronata (L.) Trel. Newcomb, Essex county. *H. D. House,* June 20, 1923. On the same collection is also found Sphaeronema Peckii Sacc. (S. caespitosa Peck, not Fckl.)

Pezicula cinnamomea (Phill.) Sacc.

This is the same as Dermatea cinnamomea Cooke & Peck, and Pezicula eximia Rehm. Doctor Peck's description is incomplete with respect to the spore measurements. He gives them as .0005 in. whereas they are over 30 μ. One was measured 36 x 18 μ. In the herbarium Doctor Peck later referred his Sandaken collection (type of Dermatea cinnamomea C. & P.) to Pezicula cinnamomea (Phill.) Sacc., and also at another time to Ocellaria aurea, which has asci 160 μ long, and is referable to Ocellaria ocellata (Pers.) Seaver[4], while Pezicula cinnamomea has asci 115–20 x 25–28 μ.

On dead branches of Populus grandidentata Michx. Newcomb, Essex county. *H. D. House,* July 1, 1923. East Springbrook near London, Ontario. *Dearness,* July 1912 (type of P. eximia Rehm). Sandaken. *C. H. Peck.* On Populus tremuloides Michx. Charlton. *C. H. Peck.*

Tympanis Cephalanthi Dearness & House, sp. nov.

Apothecia black, in clusters of two to four, arising from a thin stroma in the basal stratum of the cortex of the host, cespitosely erumpent through the cuticle, nearly plane, .4 mm wide, .35 mm high, with or in a group of somewhat similar pycnidia. Asci very regularly truncate-clavate, 45–60 μ long, 8 μ across the flat tip, 10–12 μ thick at the broadest part, the upper half crowded with minute sporidia, ascus pore not staining blue with iodine, paraphysate. Sporidia very numerous, minute, hyaline, allantoid, 3–4 x .5–1 μ.

Karner, Albany county, on dead twigs of Cephalanthus occidentalis. *C. H. Peck* (same type material as Dendrophoma Cephalanthi Peck).

Most of the units in each group and most of the groups entirely are pycnidia of the Dendrophoma, filled with remarkably much branched conidiophores bearing conidia indistinguishable in size and shape from the conidia of Dendrophoma Cephalanthi Peck,[5] which is seemingly what Doctor Peck described,

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[4] Mycologia 3: 65. 1911.

[5] Dendrophoma Cephalanthi Peck, 39th Rep't N. Y. State Mus. 45. 1886.

while he overlooked the associated Tympanis. It may also be assumed that the Dendrophoma is the conidial stage of the Tympanis here described.

Tympanis turbinata (Schw.) Sacc.

On dead stems of Viburnum alnifolium Marsh. Newcomb, Essex county. *H. D. House,* July 4, 1923. On dead stems of Diervilla Diervilla (L.) MacM. Karner, Albany county. *C. H. Peck.* On Viburnum cassinoides L. Babylon, Long Island. *D. H. House.* Neither Peck nor Saccardo give any measurements for this species. The asci are clavate, 75 x 6 μ, and the sporidia are 2 x ½ μ.

Holwaya gigantea (Peck) Durand

The conidial stage, Stilbum giganteum Peck, on decayed log of Liriodendron Tulipifera L., Oneida. *H. D. House,* September 16, 1922.

Propolidium fuscocinereum E. & E.

(Cryptodiscus angulosus Karst.)

Conidial stage, on dead branches of Salix nigra L., Albany. *H. D. House,* December 28, 1919.

Heterosphaeria Linariae (Rabh.) Rehm

Albany, on dead stems of Linaria Linaria (L.) Karst. *H. D. House,* May 19, 1922.

Phacidium Populi Lasch

The type of Phoma Populi Peck[6] (1887) is from Elizabethtown, on fallen leaves of Populus tremuloides Michx. On a collection from the same region made by Doctor Peck, on leaves of Populus grandidentata Michx. and reported by him as Phyllosticta bacteriiformis (Pass.) Sacc. is found the same kind of spores, and while not in good fruit is evidently the same as his Phoma Populi. The European type of Phyllosticta bacteriiformis may be quite distinct. Phyllosticta maculans E. & E.[7] and Septoria rhabdocarpa E. & E. are identical and all belong to Dendrophoma.

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[6] 40th Ann. Rep't N. Y. State Mus., 59. 1887 — Macrophoma Populi (Peck) Fl. Tassi, Bul. Lab. ed. Orto bot. Siena 18. 1902.
[7] Proc. Acad. Phila. 1893: 157. 1893.

The interesting fact in connection with this is that in the type material of Doctor Peck's Phoma Populi, in some of the same perithecia is found a Phacidium, which so far as the description goes is referable to Phacidium Populi Lasch. The asci are about 30 x 8 μ, fairly large for Phacidium, and the other characters are satisfactory for the species.

The Phoma described by Doctor Peck is without doubt the conidial stage and may be designated as **Dendrophoma Populi** (Peck) Dearness & House, comb. nov. Doctor Seaver[8] retains the name Phyllosticta maculans E. & E. for this species, with Peck's prior name, Phoma Populi, given as a doubtful synonym.

Coccomyces comitialis (Batsch) Dearness & House, comb. nov.

Peziza comitialis Batsch. Elench. Fung. Cont. 1: 217. t. 27, f. 152. 1786 — Sowerby, Fung. t. 118. 1797
Peziza viridis Bolton. Fung. t. 109. f. 1. 1789
Xyloma pezizoides Pers. Syn. Fung. 105. 1801
Ascobolus coronatus Schum. Saelland. 2: 437. 1803
Phacidium coronatum Fries. Obs. Myc. 1: 167. 1815
Coccomyces coronatus DeNot. in Erb. Critt. Ital. 1. no. 236.

On fallen leaves of Fagus grandifolia Ehrh. Croghan, Lewis county. *C. H. Peck* (reported as Hysterium tumidum Fr.); same host, East Berne, Albany county. *C. H. Peck;* North Elba, Essex county. *C. H. Peck.* On fallen leaves of Betula lutea Michx., North Elba. *C. H. Peck.* On fallen leaves of Quercus alba L. Oneida. *H. D. House.*

Lophodermium Abietis Rostr.

(Snyltesvampe Danmarks p. 17. 1889)

Newcomb, Essex county, on fallen leaves of Picea rubens Sargent, and less frequently on Picea mariana (Mill.) B.S.P. *H. D. House,* June 6, 1922. Similar to Lophodermium pinastri, but smaller, no ascus seen which measured over 105 μ in length. The spermogonial form, Leptostroma Abietis also present on some leaves; its sporules 2–3 x ½ μ.

Lophodermium Oxycocci (Fr.) Karst.

var. **hypophyllum** Dearness & House, var. nov.

A minute Lophodermium found on the leaves of Oxycoccus Oxycoccus (L.) Pers., at Tahawas, Essex county. *H. D.*

[8] N. Amer. Flora 6: 26. 1922.

House, August 4, 1921. It agrees with the features set forth in the incomplete description given by Fries,[9] except that in these specimens the fungus is strictly hypophyllous; the asci are 50–70 x 6 μ, and are overtopped by the club-shaped paraphyses. As a matter of record it may be placed for the present as a variety of L. Oxycocci.

Lophodermium sphaerioides (A. & S.) Duby

(Hypoderma sphaerioides Kuntze)

On languishing and fallen leaves of Ledum groenlandicum Oeder. North Creek, Warren county. *H. D. House,* June 25, 1923.

Lophodermium tumidum (Fr.) Rehm

(Hysterium tumidum Fr.; Coccomyces tumidus DeNot.)

A very conspicuous fungus, almost everywhere present in the Adirondack region, on dead fallen petioles of Sorbus americana Marsh. Indian pass, 3000 feet altitude. *H. D. House,* July 2, 1923. Calamity pond, June 20, 1923. Newcomb, June 28, 1923. Edmonds ponds (Cascade lakes). *C. H. Peck* (identified by Peck as Lophodermium petiolicolum (Fr.) Fckl.)

Hypoderma strobicola Tubeuf[10]

Parasitic on the living and languishing needles of Pinus rigida Mill. near New London, Oneida county. *H. D. House,* June 28, 1921. The sporidia are 20–27 x 3.5–5 μ, and surrounded by a gelatinous envelop 28–33 x 10–15 μ. On needles of Pinus Strobus L., Roslyn, Long Island. *J. J. Levison,* December 1, 1916.

Hypoderma rufilabrum (B. & C.) Duby

Newcomb, Essex county, on dead twigs of Acer spicatum Lam. *H. D. House,* June 20, 1923.

Pseudographis Phragmitis Dearness & House, sp. nov.

Apothecia scattered, erumpent, externally black and rugulose, at first perforate, then widely gaping, white-rimmed around the mouth,

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[9] Fries. Syst. Myc. 2: 588. 1823.

[10] Lophodermium brachysporum Rostr. Tids. Skoobrug 6: 251. 1883. Hypoderma brachyspora Tubeuf, 1895. Not Spegazzini, 1887.

250 μ in diameter at the base, 150 μ high. Asci subcylindrical, mostly reducing in size toward the summit, 60–70 x 10 μ paraphysate; sporidia three septate, hyaline, rounded at both ends, uniformly narrowing from base (3½–5½ μ wide) to summit (2½–3 μ wide), and 16–27 μ in length.

On dead culms of Phragmitis Phragmitis (L). Karst., Long Beach, Long Island. *H. D. House,* May 10, 1922.

Acrospermum cuneolum Dearness & House, sp. nov.

Perithecia thickly scattered, particularly in the angles of the branchlets, erumpent, dark brown, wedge-shaped; edge 170 μ thick at base, 50 μ at top, side 600–50 μ long, 300 μ wide, concentrically ridged. Asci various in length, up to 550 μ, 6–7 μ in width, some of them elongated to 50–80 μ below the sporidia; paraphyses filiform. Sporidia smoky hyaline in mass, filiform, various in length, the longest ones measuring over 500 μ in length by 1 μ in thickness.

On dead twigs of Acer spicatum Lam. Newcomb, Essex county. *H. D. House,* June 8, 1922.

Ostropa mellea Dearness & House, sp. nov.

Apothecia scattered, sparse, seated in the decorticated wood, externally white, furfuraceous, melleus or salmon-colored in the center of the disc, the stroma and dark part of the perithecial wall concealed, the exposed cushion circular, .5–.75 mm in diameter, rising .25–.28 mm above the wood. Asci linear-cylindrical, 300–500 x 6–9 μ, exceeded 20–60 μ by the linear paraphyses which are 1–1½ μ thick. Conidia filiform, nearly as long as their containing asci, multiseptate, the septation made plain by staining, 1 μ thick.

On decorticated wood of Platanus occidentalis L. Charlotte, Vermont. *C. G. Pringle* 490. 1880.

PYRENOMYCETES

Dimerosporium balsamicola (Peck) E. & E.

Newcomb, Essex county, on dead leaves of Abies balsamea (L.) Mill. *H. D. House,* June 12, 1921.

Meliola Cookeana Sacc.

On leaves of Solanum sp. Orange river valley near Juan Diaz, Panama. *E. P. Killip,* November 11, 1917. Appendages few, 200 x 10 μ, apex entire. A form on Bradburya angustifolia (H. B. K.) Kuntze, collected by Killip on the upper Juan Diaz river, Panama, October 23, 1917, is apparently the same species; the

spores are the same shape and size, but the perithecia seem less mature.

Asterina Killipii Dearness & House, sp. nov.

Perithecia hypophyllous, shield dimidiate, radiate-fimbriate edged, reaching 360 μ in diameter, in a reticulate, brown mycelium of anastomosing hyphae 5–6 μ thick, many of the strands opposite the middle of the mesh bearing a globular enlargement 20–25 μ thick. Asci eight-spored, flabby, various in shape and size, subovate to irregularly cylindric, 40–90 x 12–20 μ. Sporidia hyaline, irregularly oblong, 12–16 x 5–7 μ.

On languishing or dead leaves of Erythrodes Killipii Ames (Orchidaceae). Camp 1, Holcomb's trail, El Boquete, Panama, 1650 meters altitude. *E. P. Killip,* February 15, 1918. Many of the perithecia of the type material will be found in imperfect condition for study.

Micropeltis Viburni Dearness & House, sp. nov.

Perithecia membranous, scattered, sometimes very thickly so, hypophyllous, circular, dimidate, brown, opening lacerately or stellately in 3 to 6 triangular sections but remaining incurved, 85–175 μ in diameter. Asci cylindric to subclavate, sessile, 45–60 x 8–10 μ, paraphyses linear, not abundant, about the length of the asci. Sporidia hyaline, mostly biseriate, subacute at both ends, three-septate, 15–18 x 4 μ.

On dead leaves of Viburnum cassinoides L., hanging on the living twigs, Newcomb, Essex county. *H. D. House,* June 23, 1923.

Attention was attracted to several shrubs of the Viburnum growing in a swamp, the ends of all of the new shoots covered with leaves of the present season's growth which had apparently died and turned brown or almost black, just before reaching maturity. Their general appearance was similar to what might be expected as the result of a late frost, but there was no indication in the surrounding vegetation, which included some ferns which are very sensitive to light frost, that such a frost had occurred. If such a frost had occurred one would scarcely expect to find so soon afterward a secondary or saprophytic fungus coming to maturity on the leaves (June 23d). The dead leaves bear on the upper side numerous minute, sterile pycnidia, which if related to the Micropeltis, that relationship could not be established. It seems likely that the death of the leaves was due to the mycelium represented by these minute sterile pycnidia or to the Micropeltis described above.

Nectria episphaeria (Tode) Fries

A blood-red Nectria on Eutypella on beech, collected by Peck at Morehouseville, but unnamed, possesses the essential characters of Nectria episphaeria, but is smaller in every way than the measurements given in the description of the usual form. The perithecia are mostly under 100 μ in diameter; the asci 45 μ instead of 60 μ long, and the sporidia 7 x 4 μ, instead of 9–12 x 4–6 μ. It may stand for the present as var. **minor** Dearness & House, var. nov.

Thyronectria Xanthoxyli (Peck) E. & E.

On dead branches of Xanthoxylon americanum L. West Troy. *C. H. Peck,* October 1898 (type). This has been merged by Seaver[11] into T. pyrrhochlora (Auers.) Sacc. It has, however, certain distinctive characters, including smaller cespitose perithecia in smaller and less immersed stroma, which makes this disposition of the species open to question.

Balansia Hypoxylon (Peck) Atkinson[12]

On leaves of Spartina Michauxiana Hitchc. Lewis Point, Madison county. *H. D. House,* August 20, 1918. The ascigerous cells are 360 μ long; the longest asci about 270 μ long; spores nearly as long and .7 μ thick. Doctor Peck collected the type of this species at Sandlake, Rensselaer county, on Danthonia spicata (L.) Beauv.

Claviceps purpurea (Fr.) Tul.

Sclerotia on the inflorescence of Spartina alterniflora Loisel., Long Beach, Long Island. *H. D. House,* October 20, 1923. Some of the sclerotia are over 2 cm long.

Dothidella caricina Dearness & House, sp. nov.

Stromata black, covered at first by the blackened epidermis and strongly suggesting a small form of Phyllachora graminis; .15–1.5 mm in length, .15–.4 mm in width, containing one, two or three ascigerous cells, sometimes more (eleven was the largest number observed in a single stroma); ostiola black, shining, sulcate, about 50 μ in height, and of the same width, rupturing the lower, that is, the outer surface of the leaves and sheaths; asci narrowly clavate, 60–75 x 7–8 μ, eight-spored, paraphysate; sporidia hyaline, uniseptate, partially biseriate, usually nucleate and slightly curved on one side, 11–18 μ long, mostly about 15 x 3 μ.

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[11] Mycologia 1: 203–4. 1909.
[12] Journal of Mycology 11: 254. 1905.

On languishing and dead leaves and sheaths of Carex laevivaginata (Kukenth.) Mackenzie, Oneida, Madison county. *H. D. House,* June 18, 1921.

This differs from Phyllachora graminis, which is astomous and tuberculose, by its prominent perithecia. It has much smaller stromata than Scirrhia ostiolata Ell. & Galw. which it resembles in the cell contents. Some of the stromatic sections look more like Diaporthe than a Dothideaceous genus. Most of the leaves were also infected with Puccinia urticata.

Phyllachora Melicae Dearness & House, sp. nov.

Stroma oblong, ends truncate, shining, dark brown, ½ to 1 mm long, 160 μ wide (width 1-rowed loculi) to 500 μ wide (in 3-rowed examples), visible on both sides of the leaf, clypeate on the upper side. Loculi in one–three rows, stromatic on the upper side of the leaf, globular, 88–136 μ in diameter, base wall 25 μ thick, side walls 16–18 μ thick, upper with adnate clypeus 30–35 μ thick, of compact dark colored short celled parenchyma. Asci cylindric, short pedunculate, 55–62 x 7–8 μ, paraphyses linear, longer than the asci. Sporidia obliquely monostichous, hyaline, grumous, broadly elliptic, 7–8 x 5–5½ μ.

On dead leaves of Melica purpurascens (Torrey) Hitchc. (*Avena striata* Michx.), Newcomb, Essex county. *H. D. House,* June 23, 1923. This comes near Phyllachora vulgata Thiess. & Sydow,[13] which inhabits species of Muhlenbergia. Phyllachora melicicola Speg.,[14] on Melica,

Phyllachora Oryzopsidis Theiss. & Sydow[15]

On languishing and dead leaves of Oryzopsis asperifolia Michx., New London, Oneida county. *H. D. House,* July 20, 1918. The type of this species was collected by *Dearness,* at London, Ontario, on the same host species, and is represented by Bartholomew's Fungi Columbiana no. 3536.

Lasiosphaeria xestothele (B. & C.) Sacc.

This was reported by Doctor Peck[16] as Sphaeria xestothele B. & C. on birch bark, from Oneida, collected by *H. A. Warne.* Reexamination of the material shows it to be merely Rosellinia

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[13] F. Theissen & H. Sydow. Die Dothideales. Annales Mycologici 12: 450. 1914.

[14] Myc. Argent. IV. n. 710. Sacc. Syll. 22: 423. Theissen & Sydow. l.c. p. 449.

[15] Theissen & Sydow. l.c. p. 451.

[16] 30th Rep't N. Y. State Mus. 65. 1878.

aquila (Fr.) DeNot., and the name Lasiosphaeria xestothele should be for the present deleted from lists of New York fungi. The species itself is doubtful. Among some specimens in the state herbarium is one from M. A. Curtis (no. 4972), which may be cotype material of the species, collected on Cornus florida L., in South Carolina. It appears to be a species of Eriosphaeria rather than Lasiosphaeria.

Zignoella pulviscula (Curr.) Sacc.

(Z. ovoidea Fries)

Helderberg mountains, Albany county, on bark of Acer spicatum Lam. *C. H. Peck,* August (year of collection not indicated). Doctor Peck has previously reported this on decorticated wood from Buffalo, collected by Clinton. Doctor Fairman[17] reports it from Lyndonville, Orleans county, on chips of Betula lutea Michx.f.

Otthiella staphylina (E. & E.) Dearness & House, comb. nov.

Plowrightia staphylina E. & E. Proc. Acad. Nat. Sci. Phila. p. 248. July 1890
Otthia staphylina E. & E. N. Am. Pyren, 251. 1892

Albany, on dead branches of Staphylea trifolia L. *C. H. Peck,* April (year of collection not indicated). The spores are hyaline which places the species in Otthiella.

Cucurbitaria Comptoniae C. & E.

On dead stems of Comptonia peregrina (L.) Coulter (Myrica asplenifolia L.), Delmar, Albany county. *H. D. House,* December 21, 1919. The collection also contains Valsa ambiens (Pers.) Fr.

Amphisphaeria applanata (Fr.) Ces. & DeNot.

On wood of Acer spicatum Lam. East Berne, Albany county. *C. H. Peck,* August (year of collection not indicated). Spores 18–33 μ long, mostly about 22–24 x 8–15 μ, the two cells unequal.

Amphisphaeria thujina (Peck) Sacc.

Doctor Peck in the original description of Sphaeria thujina[18] does not describe the asci. Ellis[19] stated that it "may be

[17] Proc. Rochester Acad. 4: 223. 1906.
[18] 27th Annual Rep't N. Y. State Mus., 110. 1875.
[19] N. Am. Pyrenomycetes, 204. 1892.

only a Diplodia." Careful examination of the type material finally yielded mature asci. The perithecia are not typical of the genus. They are nearly twice as long as wide at the base and although pertusate, are not circularly so. The asci are eight-spored, various in shape, the longest reaching 135 μ densely paraphysate; sporidia brown, one-septate, subbiseriate to conglobate, 27–44 x 9–15 μ. On decorticated and decayed wood of Thuja occidentalis L. Adirondack mountains. *Peck*. Also collected by *Pringle*. on the same host in Vermont.

Teichospora Chevalierii Karst.

Newcomb, Essex county, on dead branches of Myrica Gale L. *H. D. House,* June 8, 1922.

This must be regarded as a tentative determination since the material is not abundant, nor is there an authentic specimen available for comparison. The measurements are approximately those of the species named. The noncollapsing perithecia contain asci weak and variable in shape, average about 120 μ in length, eight-spored, densely paraphysate; sporidia variable, about 17–21 x 9–10 μ, three-septate, constricted at the septa, becoming so opaque as to obscure the septation.

Glomerella cingulata (Stoneman) Spaulding & Von Schrenk[20]

The conidial stage, Gloeosporium cingulatum Atk. richly covering languishing and dead leaves of Camaridium grandiflorum Ames (Orchidaceae), El Boquete, Panama, *E. P. Killip,* February 18, 1918. The Gloeosporium and its ascigerous stage, Glomerella cingulata, on dying leaves of Fureraea Cabuya integra Trelease, at Bella Vista, Panama. *E. P. Killip,* September 29, 1917.

Guignardia Pleurothallis Dearness & House, sp. nov.

Perithecia epiphyllous, gregarious on areas of .5–1 cm which are greener than the surrounding portions of the leaf, finally thickly scattered over the whole leaf, dark brown, .1–.2 mm, waxy membranous. Asci fusoid or clavate, mostly about 45 x 10 μ, surrounded by a few indistinct paraphyses. Sporidia subbiseriate, grumous-hyaline, some of them curved, depending upon their position in the ascus, variable in size as well as shape, mostly 12 x 2–3 μ.

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[20] Science, N. S. 17: 750. 1903 (Gnomoniopsis, Stoneman, Bot. Gaz. 26: 101. t. VII, f. 27–28. 1898. Not Berl. 1892).

On languishing leaves of Pleurothallis ruscifolia Sw., in deep woods, valley of the Rio Piarnasta, Panama, 1500 meters altitude. *E. P. Killip,* February 25, 1918.

Guignardia caricis Dearness & House,[21] nom. nov.

Laestadia caricis Dearness & House. N. Y. State Mus. Bul. 205: 52. 1919.

On dead leaves of Carex strictior Dewey (C. stricta Auth.) northern Herkimer county. *H. D. House,* 1917 (type).

Guignardia depressa (Peck) Dearness & House, comb. nov.

Sphaerella depressa Peck. N. Y. State Mus. Rep't. 33: 34. 1880
Laestadia depressa Berl. & Vogl.; Sacc. Syll. Add. 1–4*a*: 61. 1886
Mycosphaerella depressa House. N. Y. State Mus. Bul. 233–34: 27. 1922

On dead stems of Lactuca sp. Karner, Albany county. *C. H. Peck* (type).

Guignardia smilacinae Dearness & House, nom. nov.

Laestadia smilacinae Dearness & House, N. Y. State Mus. Bul. 205: 53. 1919

On dead leaves of Vagnera stellata (L.) Morong. Karner, Albany county. *C. H. Peck* (type).

Mycosphaerella conigena (Peck) House

On cone scales of Thuja occidentalis L. Newcomb, Essex county. *H. D. House,* June 22, 1923. Doctor Peck collected the type of this in the Helderberg mountains in 1879, and also made collections of it at Elizabethtown and Newcomb.

Mycosphaerella Pontederiae (Peck) House

Newcomb, Essex county, on dead leaves of Sarracenia purpurea L. *H. D. House,* June 25, 1920. On the same leaves is Discosia artocreas (Tode) Fr.

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[21] The prior generic name Guignardia Viala & Ravaz, is used by Traverso, Lindau, Schroeter, Shear and others, in place of Laestadia Auersw, 1869, not Lessing. In addition to the three species here transferred, the state herbarium contains the following species of this genus collected in New York:

Guignardia Aesculi (Peck) V. B. Stewart
Guignardia Bidwellii (Ell.) Viala & Ravaz
Guignardia carpinea (Fr.) Schroeter
Guignardia epilobii (Wallr.) Lindau
Guignardia fraxinicola (Curt.) Lindau

Mycosphaerella punctiformis (Pers.) Johanson

On fallen leaves of Fagus grandifolia Ehrh. Oneida, Madison county. *H. D. House,* June 2, 1923.

Mycosphaerella verbascicola (Schw.) Fairman

On dead stems of Verbascum Thapsus L., Westernville, Oneida county. *H. D. House,* June 2, 1923, associated with Phoma verbascicola Sacc., with very minute spores, and which is doubtless a stage of the Mycosphaerella.

Metasphaeria aulica (C. & E.) Sacc.

On dead stems of Eupatorium purpureum L., Newcomb, Essex county. *H. D. House,* June 23, 1923. Previously reported[22] on stems of Triosteum aurantiacum Bicknell.

Metasphaeria leiostega (Ell.) Sacc.

On dead stems of Rosa blanda Ait., Newcomb, Essex county. *H. D. House,* June 28, 1923. The sporidia in this material are 8–11 μ wide, while the original description gives them as only 7–8 μ wide. Doctor Fairman[23] has reported this species from western New York.

Metasphaeria microecia E. & E.

On dead twigs of Acer spicatum Lam. Newcomb, Essex county. *H. D. House,* June 20, 1923.

Leptosphaeria borealis E. & E.

var. **Populi** Dearness & House, var. nov.

Immersed in the decorticated wood of the host, and differing from the type on Salix in the sporidia varying from three to five-septate and in being constricted at the septa. The sporidia are irregular in size and shape but are mostly 19–22 x 6–9 μ, and become very dark colored; paraphyses abundant and branching.

North Elba, Essex county, on decorticated branch of Populus balsamifera L. *C. H. Peck* (year of collection not indicated). Intermediate between Leptosphaeria borealis E. & E. and Leptosphaeria consimilis E. & E.

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[22] N. Y. State Mus. Bul. 233–34: 38. 1922.
[23] Journal of Mycology 5:79. 1889

Leptosphaeria culmifraga (Fr.) Ces. & DeNot.

On dead culms of Phleum pratense L. Newcomb, Essex county. *H. D. House,* June 21, 1923. Typical perithecia and sporidia abundant, but near the joints of the host occur larger perithecia with brown 6-septate sporidia.

Leptosphaeria dumetorum Niessl.

On dead stems of Clematis virginiana L. Newcomb, Essex county. *H. D. House,* June 22, 1923.

Ophiobolus filisporus (C. & E.) Sacc.

On dead stems of Veratrum viride L., Peterboro, Madison county. *H. D. House,* June 9, 1923. On dead stems of Scrophularia lanceolata Pursh (S. leporella Bicknell), Newcomb, Essex county. *H. D. House,* June 23, 1923.

Pleospora herbarum (Pers.) Rabenh.

On dead stems of Lathyrus maritimus (L.) Bigel. Woodville, Jefferson county. *H. D. House,* June 6, 1923. Typical and in good fruit.

var. **Triglochinis** Dearness & House, var. nov.

This interesting variety of a very common species departs from the usual form in the following particulars: ostiola stronger; asci larger, the largest ones measuring 362 x 48 μ, and are more mucilaginous, the wall being 9 μ thick and at the tip up to 16 μ thick; sporidia mostly 45–48 x 18–21 μ, in sheaths 6 μ thick; paraphyses less abundant.

On dead leaves of Triglochin palustris L. Bergen swamp, Genesee county. *C. H. Peck,* June. These mucilaginous structures in this species naturally swell and elongate by the absorption of water, but that fact does not invalidate comparisons with typical forms of the species similarly treated.

Pleospora scabra Mout.[24]

Material collected at Woodville, Jefferson county, on dead leaves and culms of Ammophila arenaria (L.) Link. *H. D. House,* June 21, 1922, is referred here with some hesitation. The paraphyses are long, and the sporidia are 37 x 12–14 μ, which with

[24] IV Not. Ascom. Nouv. in Bul. Soc. Bot. Belg. 48. 1900.

other features indicate that the fungus comes nearer to this species than to any other one described. The species was originally described from Belgium on grass culms, the exact species not indicated.

Pleospora vagans Niessl.

Long Beach, Long Island, on dead culms of Phragmitis Phragmitis (L.) Karst. *H. D. House,* May 10, 1922. On the same collection is Pseudographis Phragmitis Dearness & House, Coniosporium arundinis (Corda) Sacc., and Lophodermium arundinaceum (Schrad.) Chev., var. vulgaris Fckl.

Splanchnonema conspurcata (Wallr.) Kuntze[25]

Albany, on dead branches of Prunus serotina Ehrh. *H. D. House,* November 8, 1919. Doctor Peck collected this on Prunus americana Marsh., and Shear collected it on Prunus virginiana L. (state herbarium).

Gnonomia setacea (Pers.) Ces. & DeNot.
var. **Caryae** Dearness & House, var. nov.

The typical form of this species has sporidia 12–16 x 1.5–2 μ. The late Mr Ellis reported finding a form on Carya at Newfield, N. J. with sporidia 20–25 μ long. In a collection by Doctor Peck, we find the same form as reported by Ellis. The sporidia reach 30 x 2.75–3 μ in size, and it may be regarded as a variety.

Greenbush, Rensselaer county, on fallen leaves of Hicoria glabra (Mill.) Britton (Carya glabra Spach). *C. H. Peck,* June (year of collection not indicated).

Diatrype platystoma (Schw.) Berk.

Newcomb, Essex county, on dead branches of Acer rubrum L. *H. D. House,* July 20, 1920. Probably not rare, as Kauffman[26] reports it from North Elba on Acer, Doctor Peck has collected it on the same host at Karner and at Shandaken, and Fairman has collected it in Orleans county.

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[25] Massaria conspurcata (Wallr.) Sacc. Syll. 2: 11. 1883. The generic name Massaria DeNot. (Giorn. Bot. Ital. 1: 333. 1845), is antedated by Splanchnonema Corda, in Sturm, Fl. III (2): 115. t. 54. 1829. The type species, Splanchnonema pustulatum Corda, is identified by A. de Jaczewski (Bul. Herb. Boiss. 2: 674) as Massaria foedans (Fr.) Fckl.

[26] N. Y. State Mus. Bul. 179: 84. 1915.

Diatrypella decorata Nitschke

Newcomb, Essex county, on dead branches of Betula lutea Michx.f. *H. D. House,* June 8, 1922. Doctor Peck recorded this on the same host species from Sandlake.

Diatrypella discoidea (Cooke & Peck) Sacc.

On dead limbs of Betula papyrifera Marsh. Indian Pass, Essex county. *H. D. House,* July 15, 1923. Compared with material of D. favacea, D. betulina and D. decorata (all on Betula), which has been passed upon as authentic for the species named, by either Ellis, Farlow, Peck or Rehm. This comparison indicates that there is some confusion in regard to the status of these four species. The only clause in the description of D. discoidea discrepant with the Indian Pass material is that according to the description the large orbicular stromata have small perithecia and small, scarcely exserted ostiola, while the ostiola in the Indian Pass collection are distinct and sulcate.

Diatrypella quercina (Pers.) Nits.

East Greenbush, Rensselaer county, on dead branches of Crataegus sp. *H. D. House,* May 23, 1923. There is a collection by Peck in the State herbarium from the same locality and on the same host genus. Doctor Peck has also collected this on Crataegus at Elizabethtown, Essex county.

Valsa ceratophora Tul.

Albany, on dead stems of Cephalanthus occidentalis L. *H. D. House,* November 5, 1922.

Anthostoma amplispora (Cooke) E. & E.

On dead branches of Prunus virginiana L. Albany. *H. D. House,* December 28, 1919. Cooke's description of this species is not very complete. It states that the perithecia in a stroma are few and rather large. Some of the stroma have twelve or more perithecia, but with the exception that the perithecia can not be called relatively large, there are stromata, perithecia, asci and sporidia agreeing with his description. The type was said to be "on bark, probably of Quercus, United States."

Anthostoma cercidicolum (B. & C.; Peck) Sacc.

Diatrype cercidicola B. & C.; Peck. 25th Rep't N. Y. State Mus. 101. 1873
Hypoxylon suborbiculare Peck. 30th Rep't N. Y. State Mus. 63. 1878. Not Welw. & Curr. 1867
Nummularia lateritia E. & E. Proc. Phila. Acad. 144. 1893
Anthostoma cercidicolum Sacc. Syll. 1: 306. 1882 — E. & E. N. Amer. Pyren. 582. 1892

On dead branches of black ash, Fraxinus nigra Marsh. Newcomb, Essex county. *H. D. House,* July 20, 1920.

For a description of this species see N. Y. State Mus. Bul. 205–6: 44. 1919. It seems that Doctor Peck having at hand a specimen from Curtis labelled "Diatrype cercidicola B. & C." decided that it was the same as a collection from Buffalo by Clinton, and hence gave first definite formal publication to the name, accompanied by a description of the Clinton material and giving the black ash as the host species.

Examination of the Curtis specimen referred to shows that it is not the same as the Clinton material. The Curtis specimen came from Alabama (by Peters?), and the host is said to be Cercis, which is probably correct. What other specimens from Curtis, under this name, in other herbaria may be we do not know. Cooke[27] listed the species without comment, having previously[28] transferred the name to Fuckelia. From his treatment the inference is plain that he went by Doctor Peck's description, and that if a specimen from Curtis was at hand, he did not examine it. This follows a statement[29] that he did not have "fungus spores on the brain," and that no notes had been made. If Cooke had made a study of the Curtis specimen, it is possible that one of the worst mix-ups in mycological nomenclature might have been avoided. As the matter now stands we are obliged to retain Doctor Peck's name for the species on black ash, a misleading name based upon a misapplication of an older herbarium name.

Diaporthe acerina Peck

On dead twigs of Acer spicatum Lam., Newcomb, Essex county. *H. D. House,* June 20, 1923. In the dense thicket of Acer spicatum, where this material was collected, the following species were collected upon the same host species:

Acrosperum cuneolum D. & H.
Cenangium griseum D. & H.
Diaporthe spicatum E. & E.

[27] Grevillea 14: 16. 1885.
[28] Grevillea 12: 52. 1883.
[29] Cooke, l. c. p. 51.

Hypoderma rufilabrum (B. & C.) Duby
Leptothyrella aceris D. & H.
Metasphaeria microecia E. & E.
Ombrophila setulata D. & H.

Diaporthe aorista E. & E.

On dead stems of Aster lateriflorus (L.) Britton, Bonaparte swamp. Lewis county, *H. D. House*, June 23, 1920. On dead stems of Solidago macrophylla Pursh, Indian Pass, Essex county. *H. D. House*, July 15, 1923.

The type of this species was collected at Newfield, N. J., on host said to be Solidago.[30] Saccardo[31] in compiling the species wrongly credits it to New York State. The Indian Pass material, except for the spore measurements, seems to agree better with the published description of D. aorista than the specimens distributed in Fungi Columbiana no. 1043 and North American Fungi no. 3432. An odd sporidium is subappendiculate, and many of them are larger than the measurements given in the original description. They are nearly all flat on one side and rounded on the other, instead of oblong as described. Diaporthe exercitalis Peck is evidently closely related.

Diaporthe Arctii (Lasch) Nits.

On dead stems of Arctium minus Bernh. Peterboro, Madison county. *H. D. House*, June 9, 1923. D. Arctii is described as having inequilateral or slightly curved sporidia, and D. orthoceras as having straight sporidia and longer ostiola. The sporidia in the Peterboro material are straight, but the other features all agree with the description of D. Arctii.

Diaporthe disciformis (Hoffm.) Fr.

On dead branches of Amelanchier canadensis (L.) Medic. Albany. *H. D. House*, April 6, 1923. Apparently an unreported host for this fungus, which has been recorded from a variety of hosts, chiefly in Europe (Saccardo gives Alnus, Betula, Castanea, Fagus, Prunus, Rhamnus and Viburnum). It is recorded from none of these host genera in New York. Doctor Peck's only collection of it is on Acer spicatum Lam., from the Catskill mountains, and Fairman[32] reports it from Lyndonville, on Ribes, as forma ribincola Rehm.

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[30] Bul. Torrey Bot. Club 24: 132. 1897.
[31] Syll. Fung. 14: 549. 1899.
[32] Fairman, Annales Mycologi 8: 330. 1910.

Diaporthe impulsa (Cooke & Peck) Sacc.

Newcomb, Essex county, on dead branches of Sorbus americana Marsh. *H. D. House,* June 8, 1922.

Diaporthe megalospora E. & E.

Newcomb, Essex county, on dead twigs and branches of Sambucus canadensis L. *H. D. House,* June 23, 1923. There is present also in this collection a Metasphaeria, which may not be mature, but which is probably Metasphaeria subcutanea (C. & E.) Sacc. It differs, however, from typical examples of that species, in its sporidia being 18 x 3–4 μ, and the second cell from the top being widest (4 μ wide), subbiseriately arranged and slightly smoky in color.

Diaporthe menispermoides Dearness & House, nom. nov.

D. Menispermi Dearness & House, N. Y. State Mus. Bul. 233–34: 34. 1922. Not Speg. 1909

On dead stems of Menispermum canadense L., Albany, *House,* 1917.

Diaporthe obscura Peck

On dead stems of Rubus odoratus L. Indian Pass, Essex county. *H. D. House,* July 15, 1923. The type collection of this fungus was made by Doctor Peck near Albany on Rubus strigosus, in 1874.

Diaporthe phomaspora (C. & E.) E. & E.

Long Beach, Long Island, on dead twigs of Myrica carolinensis Mill. *H. D. House,* May 10, 1922 Newcomb, Essex county, on dead branches of Myrica Gale L. *H. D. House,* June 8, 1922. Doctor Peck has collected this at Grassy pond, Essex county, on Myrica Gale L., under the name of Diaporthe Wibbei Nitsch.[33]

Diaporthe spicata E. & E.

Newcomb, Essex county, on dead branches of Acer spicatum Lam. *H. D. House,* June 6, 1922. Previously collected by Doctor Peck at Knowersville, Albany county, on the same host species, and reported as Diaporthe myinda (C. & E.) Sacc.[34]

[33] N. Y. State Mus. Bul. 197: 28. 1918.
[34] 34th Rep't N. Y. State Mus. 52. 1881, as Valsa myinda.

Diaporthe tessera (Fr.) Fckl.

Newcomb, Essex county, on dead branches of Corylus cornuta Marsh. (C. rostrata Ait.) *H. D. House,* June 21, 1923.

Melanconis modonia Tul.

South Ballston, Saratoga county, on dead branches of Juglans cinerea L., associated with Diaporthe bicincta Cooke & Peck. Melanconis modonia has been heretofore reported only on Castanea, but the material here cited can not be referred elsewhere. The collection is by Doctor Peck, and the chambered pith of the host material makes the identification of the host species positive.

Melanconiella nigrospora (Peck) Dearness & House, comb. nov.

Diatrype nigrospora Peck. 33d Rep't N. Y. State Mus. 33. 1880
Melanconis Meschuttii E. & E. Torrey Club Bul. 10: 117. 1883
Melanconiella Meschuttii Berl. & Vogl., in Sacc. Syll. Fung. Add. 1–4*a*: 129. 1886; 9: 754. 1891
Valsaria nigrospora Berl. & Vogl., in Sacc. Syll. Fung. Add. 1–4*a*: 129. 1886

On dead branches of Betula lutea Michx.f. Quaker Street, Schenectady county. *C. H. Peck* (type). Sandlake, Rensselaer county, on same host. *C. H. Peck.*

Melanconiella subviridis (Peck) Dearness & House, comb. nov.

Melanconiella Decoraensis var. subviridis Peck; Ellis, N. Amer. Pyren. 528. 1892

Stroma circular, reaching 2 mm in diameter, depressed hemispheric, covered by the epidermis which is narrowly cleft above the group of minute ostiola, lacking any visible disk. Perithecia 10–15 in a stroma, .4–.65 mm in diameter, coriaceous, circinate around a dull greenish, pulverent core, detachable with the epidermis and leaving their impress in the surface of the unaltered cortex, necks converging not around a disk, but to a point or line and terminating in black, shining, minutely sulcate ostiola, 30–50 μ in diameter. Asci nearly sessile, cylindrical, 120–125 x 9–12 μ, paraphysate. Sporidia dark brown, uniseptate, uniseriate in the asci, the portion above the septum usually larger than the other, 18–21 x 7–10 μ.

On dead branches of Betula populifolia Marsh. Gansevoort, Saratoga county. *C. H. Peck,* September, 1886 (type).

Its associated conidial stage, **Melanconium subviridis** Dearness & House, sp. nov. is abundant in the type material, and conspicuous by its blackening the epidermis in circles 2–2.5 mm in diameter. The conidia are inequilaterally fusoid, distally rounded and sub-attenuate proximally, 17–22 x 7–10 μ.

Its size and habit of circinating between the epidermis and cortex presumably led Doctor Peck to call it Melanconiella decoraensis. Mr Ellis remarked upon the greenish, pulverulent stroma and called it variety subviridis Peck, although in the place cited by Ellis, Doctor Peck did not publish any such varietal name, nor elsewhere. In addition to the other differences are the lack of a disk, the larger asci and spores, and the marked differences in size and shape of the conidial stage.

Xylaria Castorea Berk.

Newcomb, Essex county. *H. D. House,* September 20, 1922. Hulett's Landing, Lake George. *Madge Dearness Tamblyn,* September 1, 1915.

The type of Xylaria Castorea Berk. was collected in New Zealand, but Morgan sent to M. C. Cooke specimens from Ohio which Cooke identified as this species. J. B. Ellis wrote a description of the Morgan specimens[35] which agrees with the New York material. Lloyd is disposed to regard it as a variety of Xylaria polymorpha. Doctor Peck collected it at Lowville, Lewis county, and described it as Xylaria corniformis irregularis.[36] Subsequently he made additional collections at Floodwood, Ampersand pond and North Elba, which he identified as Xylaria Castorea,[37] and also changed the name of "irregularis" on his herbarium specimens to "Castorea."

SPHAEROPSIDEAE

Phyllosticta Cyanococci Dearness & House, sp. nov.

Spots pale brown beneath, darker above, 2–5 mm broad, extending in some cases to occupy most of the leafblade, microscopically specked with very minute, whitish blisters simulating pycnidia, surrounded by a reddish brown border, .5–1 mm wide. Pycnidia erumpent, becoming black, epiphyllous, central and single on a spot, 75–100 μ; spores hyaline, bacillar 3–4 x 1¼ μ.

Quite destructive to living leaves of Vaccinium corymbosum L. (Sect. Cyanococcus), Newcomb, Essex county. *H. D. House,* July 18, 1922. Many of the large spots contain no pycnidia.

Phyllosticta limitata Peck

Williamson, N. Y., on leaves of Malus Malus (L.) Britton. *Dr F. C. Stewart,* August 28, 1902. The type of the species was

[35] N. Amer. Pyren. 666. 1892.
[36] 28th Rep't N. Y. State Mus. 87. 1879.
[37] N. Y. State Mus. Bul. 28: 228. 1899.

collected by Doctor Stewart at Floral Park, Long Island, on the same host species in 1895.

Phyllosticta minutissima E. & E.

On leaves of Acer pennsylvanicum L., Osceola, Lewis county. *H. D. House,* September 20, 1922. The spores and position agree (2 x ½–¾ μ) with the description. It lacks, however, the yellow bordering and the association with the Cylindrosporium, a curious feature of the typical western form of the species on Acer glabrum.

Phyllosticta Syriaca Sacc.

Napanoch, Ulster county, on leaves of cultivated garden okra (Hibiscus esculentus L.). *H. D. House,* August 21, 1921. In general characters this seems to be nearest to Phyllosticta Syriaca, but the spores are not uniform, taking one leaf with another, and some of them are septate. Stevens[38] reports this fungus on Hibiscus Syriacus L., from Syracuse.

Macrophoma dryina (B. & C.) Berl. & Vogl.

On dead twigs of Quercus ilicifolia Wang., and on cynipid galls (Neuroterus) on same twigs. Albany. *H. D. House,* April 28, 1923.

Macrophoma Pernettyae Dearness & House, sp. nov.

Pycnidia hypophyllous, black, innate, erumpent, subglobose, rising 1.6 mm above the ruptured cuticle and completed by a cylindrical ostiolum .1 mm high and .1 mm thick. Conidia elliptic-oblong to obovate-oblong, hyaline, clear or grumous, 21–24 x 12 μ, wall 1 μ thick.

On languishing leaves of Pernettya coriacea Kl. on the rocky summit of Chiriqui volcano, Panama, 3600 meters altitude. *E. P. Killip,* February 27, 1918. The affected portion of the leaf is paler or grayer than the adjacent unaffected surface.

SCOPAPHOMA Dearness & House, gen. nov.

Phomataceous, pycnidia with papillate or short-beaked ostiola and hyalo-scolecosporous conidia upon dendroid or scopaform conidiophores to which they are adnate by long, attenuated extensions of the epispore. Type species: Scopaphoma Corioli.

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[38] Journal of Mycology 13:69. 1907.

Scopaphoma Corioli Dearness & House, sp. nov.

Pycnidia in series along the zonal lines of the pileus of the host, chiefly near the margin, raising the surface into pustules tipped by the black, papillate ostiola, subglobose or commonly ellipsoid with longer diameter parallel to the fibres of the matrix, reaching 600 x 250 μ. Conidia when stained showing a beak 9–12 x 1.7–2 μ, plasmal portion 16–21 x 2–2½ μ, and a basal linear extension 50–150 x .3–.5 μ. The fruiting layer separates in dissection into whisk-broom like masses 120–180 μ from tips to base.

On old and somewhat dried pilei of Polystictus (Coriolus) versicolor (L.) Fr. Albany. *C. H. Peck,* June (year of collection not indicated).

Phoma glandicola Desm.

On galls of Quercus ilicifolia Wang. caused by Amphibolips ilicifoliae Boss. Albany. *H. D. House,* April 28, 1923. Spores 5–6 x 2 μ.

Phoma melaena (Fr.) Mont. & Dur.

Albany, on dead stems of Vicia tetrasperma (L.) Moench. *H. D. House,* April 25, 1922.

Phoma nervisequa (Cooke) Sacc.

On the same collection of Amphibolips galls on Quercus ilicifolia Wang., as Phoma glandicola. Spores 8–12 x 5–7 μ.

Dendrophoma Azaleae Dearness & House, sp. nov.

Pycnidia black, sparsely scattered, truncate, erumpent, seated in the cortex and rising above it .5 mm, in some cases two or three connate on a stromalike base; conidia hyaline, oblong, 8–14 x 1 μ, on densely branching, fasciculate conidiophores, separating on dissection into units resembling so many bushy fox tails.

On dead branches and twigs of Azalea periclymenoides Michx. (Azalea nudiflora of N. Y. Reports), Albany. *C. H. Peck,* May (year of collection not indicated).

Sphaeronema pallidum Peck

On dead branches of Sorbus americana Marsh. Newcomb, Essex county. *H. D. House,* June 23, 1923.

Sphaeronema pruinosum Peck

On dead branches of Amelanchier Bartramiana (Tausch) Roem. (A. oligocarpa (Michx.) Roem.), Newcomb, Essex county. *H. D. House,* June 10, 1922.

Sphaeronema Robiniae B. & C.

On dead twigs of Tilia vulgaris Hayne (T. europaea Auth.), Orient, Long Island, *Roy Latham,* April 1915. On the same material is found Melanconis tiliaceae (Ell.) E. & E.

Placosphaeria Baccharidis Dearness & House, sp. nov.

Pycnidia seated upon or immersed in a black, pitchlike stroma, developed beneath the cuticle in the cortical parenchyma between the strong fibro-vascular strands of the cortex, externally black, rough so far as emergent, internal layer of conidiophores and immature conidia whitish, 180 μ to 200 μ. Conidia finally brown, in some pycnidia continuous, in others mostly continuous but partly one-septate, the latter usually shorter and wider and nonconstricted, 16 x 12, 18 x 9–10, 27 x 8, but mostly about 20 x 9 μ, on conidiophores shorter than their length.

Associated with Creonectria purpurea (L.) Seaver, on dead branches of Baccharis halimifolia L. Long Beach, Long Island. *H. D. House,* May 10, 1922.

Macroplodia Clematidis Dearness & House, sp. nov.[39]

Pycnidia thickly scattered or closely seriate on the inner bark which is thrown off but not punctured, carbonaceous, rough, hemispheric to subglobose, basal diameter reaching 350 μ, and height 250 μ, with well-developed papillate ostiola. Conidia pale brown, elliptic-oblong, 15–20 x 6–8.5 μ, contents uniform, wall 1 μ thick.

On dead stems of Clematis virginiana L. Selkirk, Albany county. *H. D. House,* April 25, 1923. In the nomenclature of Saccardo's Sylloge this would be known as Sphaeropsis Clematidis D. & H.

Macroplodia Ellisii (Sacc.) Kuntze

Sphaeropsis Ellisii Sacc., var. Laricis Peck. 44th Rep't N. Y. State Mus. 23. 1891

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[39] Kuntze (Rev. Gen. Pl. 3: 491. 1893) has indicated the priority of Macroplodia Westendorp (Bul. Acad. Brux. II, 2: 562. 1857), over Sphaeropsis Saccardo (the type of Sphaeropsis Lev. being a Phoma)

On dead twigs and branches of Larix laricina DuRoi, Newcomb, Essex county. *H. D. House,* June 23, 1923. The type of the variety Laricis was collected by Doctor Peck at Kasoag, Oswego county. Grove[40] states, "I have proved by examination of a long and fine series of examples that Phoma Pinastri Lev. and Sphaeropsis Ellisii Sacc. are merely growth stages of Diplodia Pinastri (Lev.) Grove."

Macroplodia phomatella (Peck) Kuntze

On fallen petioles of Fraxinus americana L., Albany. *H. D. House,* May 4, 1923. Not typical, the spore content more granular than in the type, and lacking the large guttae of the latter. The spores, however, are very variable, 20–26 x 8–12 μ. The type was collected by Doctor Peck, on twigs of Fraxinus americana L., in 1897, at West Troy. On a collection by *H. D. House,* on Fraxinus americana, at East Greenbush, May 23, 1923, the terminal portion of the dead twigs (the 1922 growth) contained Phoma fraxinea Sacc., doubtless a stage of Macroplodia phomatella, which was abundant on the 1921 growth of the same twigs.

Macroplodia juglandicola Dearness & House, sp. nov.

Pycnidia very numerous, closely scattered, raising the epidermis into pustules which are ruptured over the wide ostiola, flattened and adherent to the bark and coming off with it, .75 mm in diameter, the grayish center .5 mm in diameter. Conidia elliptic-oblong, 13–20 x 6–9 μ, but mostly about 18 x 7–8 μ, of a pale brown, uniform, enucleate content, on short conidiophores 2¾–3 μ wide, associated in some pycnidia with numerous small spores 8–9 x 3 μ, of similar shape and color.

Albany, on dead twigs of Juglans cinerea L. *H. D. House,* March 10, 1922 (type) and November 26, 1915. In the nomenclature of Saccardo's Sylloge this would be called Sphaeropsis juglandicola D. & H. Sphaeropsis Juglandis E. & B., on dead twigs of Juglans cinerea L., collected at Karner, Albany county. *H. D. House,* April 22, 1915, is easily distinguished from the above species by the large single nucleus in all of the more ellipsoidal spores.

Macroplodia simillima (Peck) comb. nov.

Sphaeropsis simillima Peck. Bul. Torrey Bot. Club 36: 337. 1909

[40] Jour. of Bot. 57: 207. 1919.

Geneva, on dead twigs of Acer platanoides L. *F. C. Stewart* and *F. M. Rolfs,* April 12, 1900. Like the type of the species, collected at River Forest, Ill., in 1909, this is densely gregarious and occasionally, perhaps frequently, haplosporelloid. The pycnidial and spore measurements agree. The spores in the type material are rather uniformly binucleate, while these have regularly one large central nucleus, the only marked difference. This has also been recently reported from Long Island.[41]

Macroplodia Wilsonii (Peck) Kuntze

On dead stems of Lonicera hirsuta Eaton, Pecksport, Madison county. *H. D. House,* June 2, 1923. Apparently the only collection in this State, at least, since the type collection made by *Clinton,* at Buffalo, on "Lonicera flava."

Microdiplodia Linderae (E. & E.) Dearness & House, comb. nov.

Diplodia Linderae E. & E. Proc. Acad. Phila. 79. 1891 — Sacc. Syll. 10: 278. 1892

On dead twigs of Benzoin aestivale (L.) Nees, Woodville, Jefferson county. *H. D. House,* June 6, 1923. The type of this fungus was collected by *Ellis* at Newfield, N. J., and *Dearness* has collected it at London, Ontario. This collection from Woodville also contains Dothidea Linderae Gerard,[42] also collected by Doctor Peck at Albany, and Didymosphaeria Linderae Sacc., not previously reported from this State.

Botrydiplodia Celastri (Cooke) Sacc.

On dead stems of Celastrus scandens L., Albany, *H. D. House,* April 6, 1923.

Ascochyta Rhei E. & E.

On living and languishing leaves of rhubarb, Rheum Rhaponticum L., cultivated at Newcomb, Essex county. *H. D. House,* July 18, 1923.

Hendersonia Viburni Ell.

Albany, on dead stems of Viburnum dentatum L. *H. D. House,* November 29, 1917.

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[41] Burnham & Latham. Torreya 24: 27. 1924.
[42] Bul. Torrey Bot. Club 5: 40. 1874.

Septoria alnifolia E. & E.

Caroga, Fulton county, on leaves of Alnus incana L. *C. H. Peck,* July. This was reported by Doctor Peck[43] as Septoria alnicola Cooke. Ellis in describing Septoria alnifolia distinguished it from Septoria alnicola Cooke by the latter having oblong sporules. The sporules in the Caroga specimen are mostly linear and curved. Piper's collection on Alnus rubra Bong. from Seattle, Washington, August 1893, no. 82 (cotype of Septoria alnifolia), has sporules 1.5 μ wide, instead of 3 μ wide as stated in the original description. The Caroga collection by Doctor Peck, and a collection by Davis (on Alnus mollis, Vilas county, Wis., July 25, 1922) have sporules up to 2 μ thick, a little wider than the cotype material examined, but narrower than the description calls for.

Septoria aquilegiae Penz. & Sacc.

Woodville, Jefferson county, on living leaves of Aquilegia canadensis L. *H. D. House,* June 24, 1921.

Septoria Commonsii Ell. & Everh.

Newcomb, Essex county, on living leaves of Cirsium muticum L. *H. D. House,* August 6, 1921. Spores small and continuous, while in the more common Septoria Cirsii, they are about twice as large and septate.

Septoria conspicua E. & M.

Unadilla, N. Y., on living leaves of Steironema ciliatum (L.) Raf. *William J. Young,* September 23, 1922. Other collections in the state herbarium on the same host are: Long Island and Carrollton, *Peck;* London, Ontario, *Dearness;* Ottawa, *J. M. Macoun 180.* On Lysimachia quadrifolia L., Huntington, Long Island. *H. D. House.*

Septoria gentianoides Dearness & House, nom. nov.

S. Gentianae Dearness & House, N. Y. State Mus. Bul. 197: 35. 1918 Not Thumen.

On leaves of Gentiana quinquefolia L., Taberg, Oneida county. *House,* 1914.

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[43] 38th Rep't N. Y. State Mus. 97. 1885.

Septoria maculifera Sacc.

Saugerties, Ulster county, on leaves of Parsonsia petiolata (L.) Rusby (Cuphea petiolata Koehne). *H. D. House,* October 8, 1921.

Septoria mollisia Dearn. & House[44]

This was described as occurring on the leaves of Antennaria neodioica Greene and Antennaria canadensis Greene. It has since been found on the leaves of A. neglecta Greene, A. Brainerdii Fernald, and A. plantaginifolia (L.) Rich., and to these must be added another host, Anaphalis margaritacea (L.) Benth. & Hook., Newcomb, Essex county. *H. D. House,* June 23, 1923. The description must be modified, since on the Anaphalis material the pycnidia reach 150 μ in diameter, and what seem to be mature spores, 60–75 x 1½ μ, multiseptate, the septa being 9–20 μ apart. There are, however, many other spores here which are not distinguishable from those in the type collection on Antennaria.

Septoria Sii Rob. & Desm.

Oneida, Madison county, on leaves of Sium cicutaefolium Schrank. *H. D. House,* September 15, 1921.

Rhabdospora continua (B. & C.) Sacc.

On dead stems of Plantago major L., Albany. *H. D. House,* May 11, 1923. Also collected many years ago at Buffalo, by *Clinton,* on Plantago lanceolata L.

Rhabdospora Polygoni Dearness & House, sp. nov.

Pycnidia thinly scattered, black, subcuticular, seated on and sometimes in the surface of the stem, hemispheric, often circularly depressed around the papillate ostiolum, 200–300 μ. Sporules hyaline, continuous, long, straight and narrow, 70–90 x 1 μ.

On dead stems of Polygonum virginianum L. East Greenbush, Rensselaer county. *H. D. House,* May 23, 1923.

Sphaerographium niveum Dearness & House, sp. nov.

Pycnidia thickly scattered, seated on the cortex, immediately under the epidermis, mostly snow-white, exceptionally fuligenous or

[44] N. Y. State Mus. Bul. 188: 39. 1916.

darker, elongated conic-frustumoid, tip truncate, 125 μ wide, base 250 μ in diameter, height .5–1 mm, mostly about .7 mm. Conidia hyaline, narrowly arcuate, attenuate-acute at both ends but more acutely pointed at the upper end, obscurely septate. When stained, 1 to 5, or usually 3 septa appear. Sometimes also nucleate, 35–60 x 2½ μ, mostly 45 x 2 μ, on fasciculate, much branched conidiophores.

Newcomb, Essex county, on dead branches of Rhamnus alnifolia L'Her. *H. D. House,* June 8, 1922 and June 20, 1923. Tahawas, August 13, 1924.

Leptothyrella Aceris Dearness & House, sp. nov.

Pycnidia thickly scattered, subcircular to elongate, situated in the cortex and beneath the cuticle which it raises into pustules about .5–.8 mm broad and .06 mm high; conidia hyaline, uniseptate, narrowly elliptic, 18–21 x 3 μ, on very slender conidiophores, 10–20 μ long.

Newcomb, Essex county, on dead twigs of Acer spicatum Lam., associated with Ombrophila setulata. *H. D. House,* June 8, 1922.

Leptostroma Allii Dearness & House, sp. nov.

Pycnidia scattered, black .4–.5 mm broad, opening somewhat variously by a nearly circular to elongate gap; conidia hyaline, short-oblong, 5–6 x 3 μ, on basidia 8–9 x 2–2.5 μ.

On dead stems of Allium tricoccum L. East Greenbush, Rensselaer county. *H. D. House,* April 15, 1921.

Leptostromella Angelicae Dearness & House, sp. nov.

Pycnidia brown, subcuticular, erumpent at the stoma or slit, thickly scattered or seriate in close lines, 150–180 μ, where seriate tending to become confluent and then elongating to 2 or 3 mm. Conidia hyaline, hamate or merely curved at the upper end, 15–18 x 1 μ on long, fasciculate conidiophores, the whisk broomlike units 60–75 μ in height, suggesting Petasodes.

On dead stems of Angelica atropurpurea L. North Greenbush, Rensselaer county. *C. H. Peck,* May (year of collection not indicated). Internally this is hardly distinguishable from Leptostromella rivana Sacc., which inhabits Acer pseudoplatanus in Europe.

Leptostromella Andropogonis Dearness & House, sp. nov.

Pycnidia shining black, epiphyllous, plainly visible beneath, but opening only on the upper side of the leaf, ovate to oblong-elliptic, .75–1.75 x .5 mm, opening by an acute rift. Conidia hyaline, curved to lunate, acute at both ends, mostly uniseptate, sometimes obscurely triseptate, nucleate, not constricted, 25–45, mostly 30–33 μ long, and 3 μ wide at the middle, on conidiophores 10–30 x 2 μ.

On dead leaves of Andropogon hirtiflorus (Nees) Kunth. Piedro de Lino, Panama. *E. P. Killip,* February 24, 1918. This approaches Leptostromella septorioides Sacc. & Roum. but differs in having wider conidia, and lacks the constrictions of the conidia of L. anceps Pass.

Leptostromella septorioides Sacc. & Roum.

On Panicum sp., Rio Parnasta, Panama. *E. P. Killip,* February 9, 1918. Conidia filiform, 40–60 μ, mostly 45 x 1 μ. Externally this looks exactly like Phyllachora graminis var. Panici Shear.

HELICIA Dearness & House, gen. nov.

Leptostromaceous. Pycnidia dimidiate, surface becoming spirally ridged; ostiola depressed and more or less elongated; spores bacillar, hyaline, catenate. Distinguished from Crandallia by the well-developed ostiolum. Type species: Helicia buccina.

Helicia buccina Dearness & House, sp. nov.

Pycnidia dimidiate, dark brown, scattered 75–600 μ at first hemispheric, finally depressed hemispheric, adnate to the blackened xylem of the host, in the mature examples exhibiting a spiral ridging of the upper third of the wall terminating in the ostiolum, the wall consisting of a layer of quadrate cells about 8–10 μ in radiate disposition; ostiolum in the mature examples turned down, trumpet form, 80–340 μ long, 85 μ thick at the base, narrowing to 40 μ above and slightly enlarging at the outwardly turned mouth, resembling the tone-arm of a gramophone. The mature pycnidium with its ostiolum is not unlike a curling stone in shape with the handle pressed down. Spores hyaline, bacillar, catenate, 5–6 x 2 μ, on short conidiophores, hardly distinguishable in the dense hymenial mass.

On dead stems of Eupatorium urticaefolium Reichard (E. ageratoides L.f.), Big Indian, *C. H. Peck,* September 1877. Under the lens this might at first be taken for a Corynelia.

Catinula turgida (Fr.) Desm.

On dead branches of Corylus cornuta Marsh. (C. rostrata Ait.) Newcomb, Essex county. *H. D. House,* June 21, 1923. Also collected at Albany by *Doctor Peck,* on Corylus americana Walt., and at West Fort Ann, by *Burnham,* on Corylus cornuta.

Myxosporium Liriodendri Dearness & House, sp. nov.

Acervuli immersed, thickly and regularly scattered as dark specks on the white, soft shoots of the host, .4–.5 x .275 mm, opening by roundish or slitlike perforations of the cuticle. Conidia hyaline, navicular, binucleate, 6–10 x 2½–3 μ, mostly 8 x 2¾ μ, on basidia 10–15 x 2 μ.

On dead shoots of the first year's growth of Liriodendron Tulipifera L. Oneida, Madison county. *H. D. House,* June 24, 1922. This appears to be quite different in every respect from Myxosporium coloratum (Peck) Sacc.,[45] on dead limbs of the same host. Myxosporium longisporum Edgerton,[46] described on twigs of the same host species from Poughkeepsie, N. Y., has conidia 30–48 x 12–15 μ.

Cylindrosporium fraxinicolum Dearness & House, sp. nov.

Spots subcircular, not bounded by the veinlets, 3–8 mm in diameter, immarginate but surrounded by a pale border, 2–4 mm wide, dull reddish-yellow above, paler beneath. Small, dark, Piggotialike pycnidia hypophyllous on a few of the spots. Acervuli epiphyllous, depressed pulvinate, strictly nervisequent, circular, 80–100 μ, but often linear or interruptedly linear from ¼ to 2 mm along a nerve, colorless or concolorous. Conidia hyaline, linear, nearly straight, nucleate, continuous or obscurely one to three septate, 18–30 x 2 μ.

On living leaves of Fraxinus americana L. Bolton, Warren county. *H. D. House,* July 20, 1917. This has been carefully compared with authentic material of four other species of Cylindrosporium occurring upon Fraxinus, and differs from all of them by the circular banded spots, nervisequent acervuli and narrowness of the sporules.

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[45] Saccardo. Syll. Fung. 3: 722. 1884 — Melanconium coloratum Peck, Bul. Torrey Bot. Club 10: 74. 1883.
[46] Edgerton. Annales Mycologi 6: 53. 1908.

Melanconium betulinum Schum. & Kze.

On dead limbs of Betula alba (cultivated), Albany. *H. D. House,* August 30, 1919. Spores 12–15 x 7–8 μ, many of them one-guttate.

Melanconium parvulum Dearness & Bartholomew[47]

On dead branches of Betula populifolia Marsh. Karner, Albany county. *C. H. Peck* (year of collection not given). On this material Melanconium parvulum seems to be confined to the smaller branches and twigs, while on the larger portions is found Melanconium stilbostoma Fr. Also collected in Washington Park, Albany, by *S. H. Burnham,* February 22, 1912, and identified as M. betulinum. The type of M. parvulum was collected at Lake Huron, Canada, in 1912, by Dearness.

Melanconium Typhae Peck

On dead leaves of Typha angustifolia L. Castle swamp, Oneida, Madison county. H. D. House, June 9, 1923.

Septomyxa grisea Dearness & House, sp. nov.

Acervuli gray, thickly scattered, circular, elongate, angular, intercortical, rupturing the epidermis which remains as a cap or partial lid for the convex spore mass, .5–2 mm. Spores elliptic, gray in mass, walls 1 μ thick, uniseptate, uniform content, 10–18 μ long, mostly 16 x 4–6 μ.

On dead twigs of Salix sericea Marsh. New London, Oneida county. *H. D. House,* June 1, 1923.

Marssonina Violae (Pass.) Magn.

Newcomb, Essex county, on living leaves of Viola cucullata Ait., and Viola septentrionalis Greene. *H. D. House,* July 22, 1922.

Coryneum Cydoniae Dearness & House, sp. nov.

Acervuli reddish brown, conspicuous by their size and the upturned cuticular wall surrounding them, irregular in shape and size, from minute dots to areas 2 mm wide and by confluence 6 mm long, in which several centers of growth can be distinguished.

[47] Mycologia 8:105. 1916.

Conidia separably amber colored, ranging in length from 33 to 45 μ, and in width from 14 to 20 μ, on stout conidiophores 6–20 x 6–8 μ.

On dead branches of Cydonia japonica Pers., Skaneateles, Onondaga county. *I. D. Smith,* April 29, 1921.

Pestalozzia funerea Desm.

On dead foliage and twigs of Thuja occidentalis L., hanging on the living trees, Houseville, Lewis county. *H. D. House,* June 8, 1923.

Pestalozzia Gaultheriae Dearness & House, sp. nov.

Acervuli amphigenous, but mostly hypophyllous, dark brown, erumpent and margined by the ruptured cuticle, 90–200 μ. Conidia fusoid, inequilaterally curved, 15–24 x 4.5–6 μ, four septate, the end cells hyaline, the three interior cells pale brown, the apical cell crowned by three or occasionally four hyaline setulae of different lengths, the longest sometimes exceeding the length of the body of the conidium, but mostly about 6.5–16 μ in length.

On dead leaves of Gaultheria sp. summit of Piedro de Lino, Panama. *E. P. Killip,* February 24, 1918. Pestalozzia gibbosa Harkness, and P. Sydowiana Bresadola, inhabit Gaultheria leaves, but both are epiphyllous and have conidia larger than the one here described.

Septogloeum Apocyni Peck

Newcomb, Essex county, on leaves of Apocynum androsaemifolium L. *H. D. House,* August 2, 1921.

HYPOMYCETES

Diplosporium flavidum Dearness & House, sp. nov.

The yellowish masses of hyphae and spores appearing in the lenticels of the host, also on the cut surface of the wood. Hyphae 10–12 μ thick at the base, irregularly branching in a dendritic manner, reducing finally to elongated, weak and mingled branches of about 3 μ in thickness. Conidia subobovate, uniseptate, hyaline like the hyphae under the microscope, 14–27 x 8–15 μ, mostly about 20 x 10 μ, rounded at the upper end and obtusely pointed at the lower end; wall 2 μ thick.

On Betula alba L., which had been in a damp cellar for some time. Albany, *H. D. House,* November 23, 1919. The limbs from which these chunks of wood were cut had been killed by the bronze birch borer (Agrilus anxius Gory).

Diplosporium Polypori Dearness & House, sp. nov.

Yellow; the individual hyphae long and irregularly branched, white, 3–8 μ thick. Conidia yellow, subglobose to oblong-elliptical, granular, smooth, uniseptate, exceptionally two-septate, 8–20 x 6–12 μ mostly about 15 x 10–11 μ.

On old pilei of Polyporus fissus Berk. (P. picipes Fr.), North Elba, Essex county. *C. H. Peck,* October 1907.

Ramularia Chamaenerii Rostrup

On living and languishing leaves of Epilobium angustifolium L., Hart lake, Adirondack lodge, near North Elba, Essex county. *H. D. House,* July 14, 1923. This material exhibits narrower spores than the original description calls for.

Ramularia Ranunculi Peck

On leaves of Ranunculus recurvatus Poir. Newcomb, Essex county. *H. D. House,* June 7, 1921.

Septoriopsis leptosperma (Peck) Davis

On living leaves of Aralia nuducaulis L., Indian pass, Essex county. *H. D. House,* June 23, 1923. Doctor Peck collected the type of this in 1884 at Aiden Lair, and also made later collections of it at Grassy pond, Essex county, and at Star lake, St Lawrence county.

Septocylindrium aromaticum Sacc.[48]

Examination of the type of Cylindrosporium Acori Peck[49] collected at Sandlake, on Acorus Calamus L., shows that the tufts are superficial but on such inconspicuous hyphae that it belongs in Septocylindrium, and differs in no essential feature from the description of S. aromaticum by Saccardo. Von Hohnel[50] states that Saccardo's species is a true Ramularia and transfers it to Ramularia aromatica (Sacc.) Von Hohnel.

Septocylindrium Ranunculi Peck

On living leaves of Ranunculus abortivus L., Wemple, Albany county. *H. D. House,* August 23, 1921.

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[48] Michelia 2: 639. 1882 — Syll. 4: 224. 1886.
[49] 46th Rep't N. Y. State Mus. 32. 1893.
[50] Annales Mycologi 3: 189. 1905.

Ellisiella caudata Sacc.

West of Albany, on dead leaves of Sorghastrum nutans (L.) Nash. *H. D. House,* October 15, 1923. The chief character upon which Ellisiella rests is that the spores are attenuated into a base or pedicle, a character which this collection abundantly confirms. Saccardo's description of this genus and his remark on the type species, " deorsum (an quandoque apice ?)" shows that he held the view that the spores might possibly be attenuated upwards, which is not the case.

Cladosporium herbarum (Pers.) Link

On dead stems of Abutilon Theophrasti Medic., Lansingburgh, Rensselaer county. *H. D. House,* May 14, 1923. Recorded as an addition to the large number of host plants in this State for this common fungus.

Helminthosporium macrocarpon Grev.

Karner, Albany county, on dead twigs of Quercus ilicifolia Wang. *C. H. Peck.* Thumen's M. U. no. 1168, collected by Doctor Peck in 1877, is on this host. Other collections by Doctor Peck are on Corylus americana Walt., Carpinus caroliniana Walt., Acer saccharum Marsh., Acer spicatum Lam. and Tilia americana L.

Helminthosporium naviculatum Dearness & House, sp. nov.

Fertile hyphae erect or spreading, simple or sparingly branched, dark brown, septate, septa about 15 μ apart, 4–6 μ across. Conidia brown throughout, subacute at both ends, naviculate, equilateral, seven to nine septate, nucleate, 30–45 μ long, mostly 9 μ in width at the middle septum.

On dead herbaceous stems (probably Solidago), Bethlehem, Albany county. *C. H. Peck* (year of collection not indicated).

Helminthosporium Phomatae Dearness & House, sp. nov.

Hyphae densely fasciculate, septate, septa 20–30 μ apart, subflexuous, dark brown, 30–180 x 6–7 μ. Conidia subcylindric to oblong-clavate, truncate at one end, often at both ends, one to three septate, usually slightly curved, sometimes quite straight, pale brown throughout, 27–45 x 6–9 μ.

Strictly parasitic on some immature sphaeropsidale, 90–150 μ in diameter, showing an occasional macrophomoid or diplodinoid conidium 20 x 10 μ; on bark of Acer pennsylvanicum L., Catskill mountains. *C. H. Peck* (date of collection not indicated).

The conidia are distinctly different from those of Helminthosporium episphaericum C. & P., occurring on "some effete Diatrype," which proves on careful examination to be Melogramma Bulliardi Tul. The conidia of H. Phomatae are smaller, more uniformly colored and lack the characteristic thickening of the second and third cells which occurs in H. episphaericum.

Cercospora avicularis Winter

On leaves of Polygonum aviculare L., Monroe, Orange county. *C. H. Peck,* July (year of collection not indicated).

Cercospora caricina Ell. & Dearn.

Newcomb, Essex county, on leaves of Carex arctata Boott. *H. D. House,* July 21, 1922. Also collected by Doctor Peck at North Elba on Carex lacustris Willd. Superficially hard to distinguish from Cercospora microstigma Sacc., but there are marked differences in the spores.

Cercospora Cypripedii Ell. & Dearn.

Newcomb, Essex county, on living and languishing leaves of Cypripedium reginae Walt. *H. D. House,* August 4, 1921.

Cercospora elongata Peck

On living and languishing leaves of Dipsacus sylvestris L. near Oneida in Oneida county. *H. D. House,* September 16, 1923. The type was collecteed by Doctor Peck at Jamesville, Onondaga county.

Cercospora Gentianae Peck

Newcomb, Essex county, on living and languishing leaves of Gentiana linearis Froel. *H. D. House,* August 4, 1921. The largest spores in this material are up to 90 μ in length, and exceed the measurements given by Doctor Peck.

Cercospora omphacodes E. & H.

On living and languishing leaves of Phlox divaricata L. Oneida, Oneida county. *H. D. House,* May 15, 1920, and near Henderson Harbor, June 7, 1923.

Acrothecium melanoplus (Schw.) Sacc.

On leaves of Allium canadense L., in fields and woods near Rensselaer. *H. D. House,* May 27, 1921. The fungus attacks the leaves usually near or below the middle, sometimes higher up. The leaf soon dies at the point of attack and the terminal portion falls over and shrivels up. Subsequently the fungus invades practically the entire leaf.

Macrosporium Martindalei Ell. & Mart.

Oneida, Madison county, on dead shoots of Liriodendron Tulipifera L., associated with Myxosporium Liriodendri Dearness & House, and a Vermicularia. *H. D. House,* June 24, 1922. Macrosporium Martindalei was described on the leaves of Magnolia glauca L. as having spores 35–50 x 18–22 μ. The spores here are narrower, the widest ones scarcely 18 μ, but otherwise agreeing with the description by Ellis and Martin.

Didymobotryum corticalis (Cooke & Peck) Dearness & House, comb. nov.

Periconia corticalis Cooke & Peck. N. Y. State Mus. Rep't 29: 52. 1878
Sporocybe corticalis Sacc. Syll. 4: 604. 1886

Near Lake Colden, Adirondack mountains, Essex county, on bark of Thuja occidentalis L. *C. H. Peck,* 1875 (type). On decorticated wood of Pinus sp. Lake Pleasant, Hamilton county. *C. H. Peck.*

The spores in the type are about 8 x 2.75 μ, most of them are continuous; some are continuous and nucleate, some are septate, and some are septate and nucleate. The application of the rule of septation, regarding the septate spores as the more mature, would place this in the genus Didymobotryum.

Tubercularia Ailanthi Cooke

On dead branches of Ailanthus altissima (Mill.) Swingle (A. glandulosus Desf.), Albany. *H. D. House,* May 4, 1923.

Hymenula Phytolaccae Berk.

Bethlehem, Albany county, on dead stems of Phytolacca americana L. *C. H. Peck,* October (year of collection not indicated, and no notice of it appears in Doctor Peck's notebooks).

A CONVENIENT LABORATORY PLANT PRESS[1]

BY

H. S. JACKSON

The drying of plants is at best a laborious and uninteresting, though very necessary, phase of the making of an herbarium and in the preservation of plants for illustrative or class study purposes. The old system of changing dryers has, in large part, given way in recent years to more modern and timesaving methods. The introduction of the use of[2] corrugated strawboard between the dryers and the utilization of some source of artificial heat for drying the plants has taken much of the drudgery from the old methods and in general has resulted in a better quality of herbarium material.

The writer has used a simple type of plant press during the past 12 years which has proven very practical and satisfactory for general laboratory purposes. On account of the simplicity of construction and the low initial cost of this apparatus, it has seemed desirable to furnish a description of it with specifications and illustrations for the benefit of those who may not have solved the problem of drying plants to their satisfaction.

The first press of the sort to be described was constructed in 1911 for use in the laboratories of the department of botany and plant pathology at the Oregon Agriculture College. From one to four of them have been in constant use there since that time both for general laboratory purposes and for use in connection with classes in taxonomic botany. The writer has also used since 1915 presses of similar construction in the botanical department of the Purdue Agricultural Experiment Station. A number of persons[3] from other institutions who have seen these presses in use at one or the other of these places have adopted a similar type.

The apparatus consists essentially of a box with rack on which the plant press rests, provided below with a source of heat (figure 2). The box is 15 by 18½ inches, inside measurement, and is open at

[1] Reprinted with minor changes from the Proceedings of the Indiana Academy of Science, 1920: 183–86. 1921.

[2] Ricker, P. L. Directions for Collecting Plants. Bureau of Plant Industry, U. S. Dep't of Agriculture Circ. 126 : 27–35. 1913.

[3] A plant press constructed according to the plans furnished by Doctor Jackson was installed in the State Botanist's office early in 1921, and has proven to be of great value not only as a timesaver, but also in its capacity for drying larger quantities of plants than could be handled by the old method of changing dryers every day. The specimens are uniformly better than those secured by any other method of drying heretofore tested in this office.

top and bottom. It may be made square 18½ by 18½ inches if desired. The sides are made of one-inch boards, 10 inches wide and fastened together with screws. A rack on which the press rests (figure 3) is provided, and placed 3 inches from the top of the box.[4] This is made of material 1 inch square and is fastened all the way around inside of the box with screws. One or two crosspieces are added as illustrated, though they are perhaps unnecessary. Yellow poplar lumber is found to be very satisfactory as it is not so liable to warp as some other kinds.

Heat may be conveniently supplied by two or three carbon filament electric light bulbs, the sockets for which are fastened about 3 inches from the bottom. Two 16-candle power lights are sufficient for ordinary purposes, dependent somewhat upon the succulence of the plants to be dried. It is well, however, to provide three sockets placed in such a way as to give the most uniform distribution of heat. The writer has also used with entire satisfaction special heating units of low resistance so constructed as to fit in any standard electric light socket. Any convenient method of supplying heat by electric current may be used. It is important, however, that only a small amount of heat be supplied.[5] It is only necessary that a draft of warm air pass through the corrugated boards of the press. Three one-inch auger holes 2 inches from the bottom are provided on each side of the box to allow for intake of air.

The sides of the press are made of one-inch boards 12½ by 18 inches. It is best to fasten a piece 1½ inches wide crosswise at either end to prevent warping. This should be tongued and grooved and glued. Canvas straps with friction buckles are permanently fastened to the boards at either end as shown in the illustration. These should be of such length as to allow for the maximum expansion which the width of the box permits with sufficient additional length to conveniently allow for drawing the press tight. If desired, ordinary woven fabric or leather trunk straps may be used, either loose or nailed to one side of the press. It is important, however,

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[4] In the press used by the State Botanist's office this rack is placed only 2 inches from the top of the box which permits the straps on the plant press to be placed correspondingly nearer the sides than is indicated in figure 2. Heat is supplied by two 32-candle power carbon filament electric light bulbs, placed at opposite ends of the box, one slightly to the right of the middle, the other slightly to the left of the middle.

[5] To learn what, if any, danger from fire existed in this press, the one at Albany was tested. The use of three 32-candle power lights caused the bottom of the press to become scorched but it would not ignite. With only two candles in operation both paper and cloth in direct contact with the bulbs ignited within a few minutes, especially when the top of the box was closed by the plant press. If resting upon asbestos board and if nothing comes in contact with the bulbs, the press appears to possess no fire hazard.

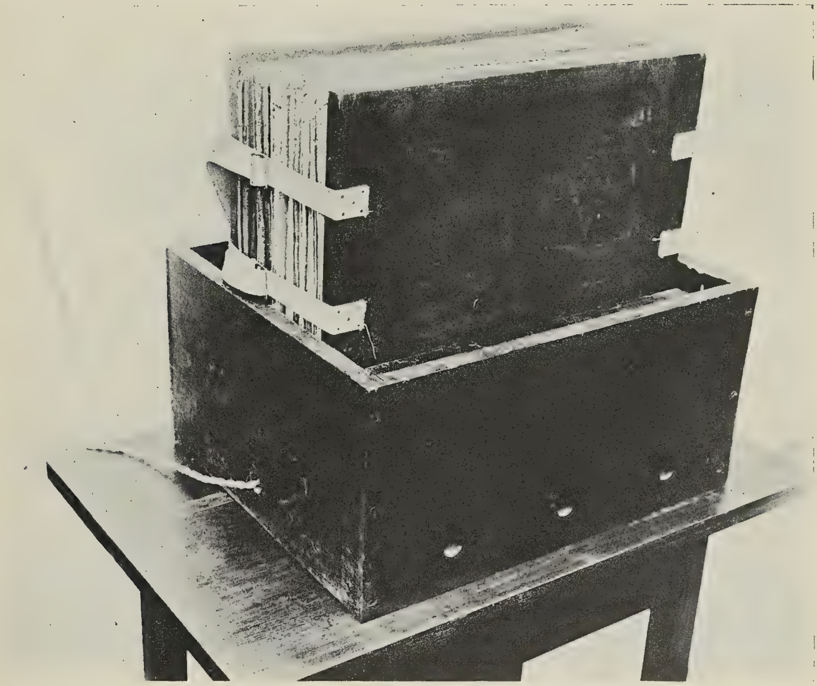

Figure 2 THE PLANT PRESS IN USE

Double-faced corrugated cardboards, cut so that the corrugations extend the short way, are used between dryers. Heat is supplied by two or three carbon filament electric light bulbs, or by special heating units constructed to fit an ordinary electric light socket.

Any thickness of press, within the limits of the width of the box, can be used. Boards 1½ or 3 inches wide are provided to fill in the space at the sides of the press on the rack when only a small amount of material is to be dried.

Ventilation is provided by six one-inch auger holes placed three on each side of the box, 2 inches from the bottom.

(*Photo by M. W. Gardner*)

Figure 3 BOX RAISED ON EDGE TO SHOW CONSTRUCTION

The inside dimensions of the box are 18½ x 15 inches. The sides are 10 inches high, open at the top and bottom. Sockets for electric lights are placed 3 inches from the bottom and the rack upon which the press rests is 3 inches from the top.

The press is made from one-inch boards, 12½ x 18 inches. Canvas straps with friction buckles are provided at either end as illustrated.

Note the loose boards which are used for a floor at sides of press when only a small quantity of material is being dried.

(*Photo by M. W. Gardner*)

that they be placed lengthwise of the press. If they are placed around the short way of the press it will not be possible to fit the loose boards, mentioned below, closely at the sides and heat will be lost. Doublefaced corrugated strawboards are cut so that the corrugations run the short way (crossways) and are used between the dryers. When succulent material is to be dried it is perhaps preferable to use one corrugated board between each pair of dryers. For the ordinary type of material two plant sheets with three dryers between each pair of corrugated boards is found entirely satisfactory. Grasses and other similar plants will be found to dry satisfactorily when three specimens and four dryers are placed between the corrugated boards. Folded sheets of newspaper are found to be entirely satisfactory for use as plant sheets, though the special sheets for sale by all dealers in herbarium supplies are preferred by many collectors. When plants are being dried for illustrative purposes a layer of sheet cotton may be used to advantage between the specimen sheets and the dryers.

When only a few plants are to be dried and the press is thin, a floor of loose but closely fitting boards should be laid on each side of the press on the rack so that all of the heat will be forced through the corrugated boards. For this purpose four boards 18 inches long, two of which are 1½ inches, and two 3 inches wide, should be kept conveniently at hand.

Most material will dry in this press in less than 24 hours although very succulent plants will require a longer time. Attempts to hasten the drying of succulent material by the application of more heat may only serve to either scorch the plant press or spoil the specimens. If one plant dryer is not capable of handling the collections desired, a second one should be added, or more as are needed. If the plant press is turned over every few hours during the early part of the drying period the plants will dry in a shorter time. As the plants become dry considerable shrinkage occurs and it is desirable to tighten the straps once or twice.

Where large quantities of plants are being dried at one time the apparatus described may not prove as satisfactory as some other methods in use, although a battery of four or five such presses will be found to be ample for ordinary class work. For the laboratory or herbarium which has only occasional use for a plant press, or for the individual collector, to whom time is valuable, it will, we believe, be found quite satisfactory. It should also be useful in high schools and vocational schools.

THE RARE PLANTS OF BERGEN SWAMP

BY

M. S. BAXTER AND H. D. HOUSE

The region known as Bergen swamp covers several hundred acres in the townships of Bergen and Byron in the northwest corner of Genesee county. It is drained by Black creek which flows eastward and empties into the Genesee river near Chili. That particular portion of the swamp which has been famous among botanists for more than three-quarters of a century is located about 4 miles west of Bergen, and near the Bergen and Byron township line, and a few rods north of the West Shore railroad at this point. It consists of an irregular open marl bog partially surrounded by a dense cedar swamp.

In dry weather the surface of the marl bog (figure 4) becomes desiccated and apparently contains little moisture, but in wet weather it is soft and miry, but never dangerous to walk upon. Few other places in New York exhibit similar ecological conditions, and probably none upon such a large scale and with such a large array of plants, which owing to the peculiar ecological conditions necessary for their growth, are for the most part extremely rare elsewhere in the State. Some of them, indeed, are found nowhere else.

Among the earlier botanists who explored this swamp are C. M. Booth, G. T. Fish, George W. Clinton, J. H. Paine jr, S. M. Bradley and Charles H. Peck. Later botanists in large numbers have added many species to the known vegetation of this unique swamp. Apparently the only species observed here by the earlier botanists which has never been found elsewhere in the State is Houghton's goldenrod (Solidago Houghtoni Torrey & Gray), although several other species, formerly found also in similar but smaller swamps eastward to Syracuse, are probably now to be found only in Bergen swamp.

The gradual disappearance of certain wild plants from our flora in many cases can not perhaps be avoided owing to the exigencies of settlement and civilization. The famous "Lodi swamp" on the outskirts of Syracuse which formerly contained a number of the rare plants now found in Bergen swamp, has entirely disappeared. Other swamps of this nature have been either drained or subjected to conditions which have altered the nature of the vegetation. It is sincerely to be hoped that some way may be found to preserve Bergen swamp as a wild life refuge, for not only is the swamp the

home of many rare and beautiful plants, but also the home of a large number of beneficial birds and harmless quadrupeds, and other interesting forms of wild life.

To botanists, of course, the peculiar interest in the swamp lies mainly in the abundance here of a large number of plants which occur so sparingly in other portions of the State.

Paine, in his Catalogue of the Plants of Oneida County (which was actually a flora of most of the State north of the lower Hudson valley) records the following species from Bergen swamp:

Aira caespitosa L.
Arethusa bulbosa L.
Carex Buxbaumii Wahl.
Carex Crawei Dewey
Carex eburnea Boott.
Carex gynocrates Wormsk.
Carex Oederi Ehrh.
Carex prairea Dewey.
Carex sterilis Willd.
Carex vaginata Tausch
Calopogon pulchellus R. Br.
Calypso borealis Salisb. (C. M. Booth)
Comandra umbellata Nutt.
Cypripedium candidum Muhl.
Eleocharis rostellata Torrey
Galium boreale L.
Juncus balticus Willd.
Juncus acuminatus Michx.
Juniperus sabina var. prostrata Pers.
Liparis Loesellii Rich.
Microstylis monophyllos Lindl.
Myrica cerifera L. (now known as M. carolinensis Miller)
Phragmitis communis Trin.
Potentilla fruticosa L.
Rynchospora capillacea Torrey
Salix candida Willd.
Scirpus caespitosus L.
Scirpus pauciflorus Lightf.
Scirpus Torreyi Olney.
Senecio balsamitae T. & G.
Solidago Houghtonii T. & G.
Solidago ohioensis Riddell
Tofieldia glutinosa Willd.
Triglochin maritimum L.
Triglochin palustre L.
Triticum caninum L.
Valeriana sylvatica Banks.
Zygadenus glutinosa Nutt.

As far as the present writers are aware the only species in the above impressive list which has not been recently collected there are Calypso borealis and Scirpus Torreyi. It is true that considerable lumbering has occurred in the surrounding woods, but that has seemingly caused little harm to the plants of the open marly bog sections and the rare plants found there seem to

Figure 4 One of the marly bog areas in the center of Bergen swamp, showing the general habitat of *Cypripedium candidum*, *Arethusa bulbosa*, *Comandra umbellata*, *Parnassia caroliniana*, *Scirpus cespitosus*, *Triantheria glutinosa*, *Solidago houghtonii*, *Anticlea elegans*, *Myrica carolinensis*, etc.

be in no immediate danger of extermination. Any proposed attempt to drain the swamp or its surrounding swampy forest, however, would forever obliterate what is at the present time one of the most unique swamps in the State, and one which should be preserved and protected not alone for the scientific interest which attaches to its vegetation but also as a refuge for a large and varied fauna of bird life. The preservation of such areas as bird refuges is highly economic because of the beneficial habits to agriculture of the birds which find such an area suitable for their nesting and food requirements.

It was at first the intention of the writers to add to this account a list of the plants now known to occur within the region known as Bergen swamp. It seems, however, that such a list should be correlated with an ecological study of the region, which at this time can not be made, and our account of the vegetation of the swamp may be limited merely to the listing of some of the less common plants or plants of peculiar interest, not noted in Paine's flora of Oneida county:

Dryopteris cristata (L.) A. Gray
Dryopteris Clintoniana (D. C. Eaton) Dowell
Dryopteris Goldiana (Hook.) A. Gray
Phegopteris Dryopteris (L.) Fee
Equisetum fluviatile L.
Lycopodium lucidulum Michx.
Lycopodium obscurum L.
Picea mariana (Mill.) B. S. P.
Taxus canadensis Marsh.
Scheuchzeria palustris L.
Panicum Lindheimeri Nash
Trisetum pennsylvanicum (L.) Beauv.
Eleocharis acuminata (Muhl.) Nees
Rynchospora alba (L.) Vahl
Mariscus mariscoides (Muhl.) Kuntze
Carex rosea Schk.
Carex trisperma Dewey
Carex bromoides Schk.
Carex cephalantha (Bailey) Bickn.
Carex incomperta Bickn.
Carex Bebbii Olney
Carex cristatella Britton
Carex leptalea Wahl.
Carex pedunculata Muhl.
Carex aurea Nutt.
Carex anceps Muhl.
Carex Shriveri Britton
Carex lacustris Willd.
Carex flava L.
Carex pseudocyperus L.
Calla palustris L.
Juncus Dudleyi Wiegand
Juncus brachycephalus (Engelm.) Buch.
Clintonia borealis (Ait.) Raf.
Vagnera trifolia (L.) Morong

Cypripedium reginae Walt.
Cypripedium parviflorum Salisb.
Cypripedium acaule Ait.
Coeloglossum bracteatum (Willd.) Parl.
Limnorchis dilatata (Pursh) Rydb.
Lysias orbiculata (Pursh) Rydb.
Blephariglottis Blephariglottis (Willd.) Rydb.
Pogonia ophioglossoides (L.) Ker.
Ophrys cordata L.
Peramium pubescens (Willd.) MacM.
Alsine longifolia (Muhl.) Britton
Neobeckia aquatica (Eaton) Britton
Sarracenia purpurea L.
Drosera rotundifolia L.
Parnassia caroliniana Michx.
Saxifraga pennsylvanica L.
Mitella nuda L.
Dalibarda repens L.
Rhus Vernix L.
Acer spicatum Lam.
Rhamnus alnifolia L'Her.
Hypericum boreale (Britton) Bicknell
Pyrola chlorantha Sw.
Pyrola uliginosa Torrey
Pyrola secunda L.
Lonicera oblongifolia (Goldie) Hooker
Lobelia Kalmii L.
Viola nephrophylla Greene?
Solidago uliginosa Nutt.
Solidago ulmifolia Muhl.
Solidago uniligulata (DC.) Porter
Aster junceus Ait.

GENERAL NOTES

Additional Myxomycetes from the Cayuga Lake Basin

Since the appearance of the Preliminary list of Myxomycetes of the Cayuga lake basin,[1] numerous gatherings of specimens have been made and studied, as a result of which the following species are added to the list already known to occur in this region. Specimens are preserved in the collections of the writers.

Badhamia lilacina (Fries) Rost.

Growing in considerable masses on mosses in Woodwardia swamp near Freeville, Cortland county, July 23, 1922. Collected by *Wann and Muenscher.*

Cribraria languescens Rex

On decayed wood, in Cascadilla gorge, Ithaca, Tompkins county, July 8, 1922. Collected by *F. B. Wann.*

Physarum connatum Lister

On bark of decaying Populus grandidentata Michx., Coy Glen, Ithaca, Tompkins county, December 5, 1922. Collected by *Wann and Muenscher.*

Physarum gyrosum Rost.

On leaves of cucumber vines, Forest Home, Ithaca, Tompkins county, July 1922. Collected by *F. Dickson.*

Physarum lateritium Morgan

Aurora, Cayuga county, July 21, 1923. Collected by *F. B. Wann.*

F. B. Wann and W. C. Muenscher
New York State College of Agriculture, Ithaca, N. Y.

Rhododendron maximum L. in Genesee County

An area of about 3 acres in the Oak Orchard swamp, Genesee county, contains many fine specimens about 10 feet high. The exact location is almost on the Alabama and Oakfield town line,

[1] Wann, F. B. & Muenscher, W. C. Mycologia 14: 38–41. 1922.

about a mile south of the Orleans county line. Collected in flower, July 22, 1917 (no. 5890) in the herbarium of Cornell University.

W. C. Muenscher
New York State College of Agriculture, Ithaca, N. Y.

Polyporus delectans Peck, at Ithaca

A fine large specimen of this species was gathered from the end of a sawed-off elm log, Inlet flats, at the head of Cayuga lake, November 9, 1919. The specimens collected by the writer are in the herbarium of C. G. Lloyd, who makes the determination.

W. C. Muenscher
New York State College of Agriculture, Ithaca, N. Y.

A Sequoia far from Its Home

While on a collecting trip along the eastern side of Cayuga lake, in central New York, my attention was called to an unusual appearing tree standing in an open field. A closer examination proved it to be a California big tree, Sequoia gigantea. Since this species is generally considered not hardy north of Philadelphia, I think a few brief notes on its occurrence here might be of interest.

The tree stands in an open field on " Dunkirk stony clay " soil, near the edge of the village of Aurora. The exact location is about 200 yards from the edge of Cayuga lake on a gentle slope that is exposed to the cold winds from the lake. The nearest other tree is a huge white oak, Quercus alba, which stands about 100 feet east of the Sequoia.

The Sequoia tree is at least 60 feet high and the base of its tapering trunk is 4 feet in diameter. The lower branches have been cut off for a distance of over 30 feet up the trunk. The upper branches are in good condition and are covered with dark green leaves. With the aid of field glasses, numerous well-developed cones were observed in the top of the tree. None of the cones that were picked up on the ground beneath the tree contained fertile seeds. The cones on the tree were inaccessible so they could not be examined for seeds.

According to statements by the present owner of the land, the tree was brought from California by an old sea captain between 1820 and 1830. In 1850 this property was purchased by the father of the present owner who was much interested in trees and took special care of this Sequoia. The soil around this tree was not plowed but it was frequently fertilized with manure. The tree has always been hardy and never suffered from cold winters until the

severe winter of 1917–18, when most of the lower branches were removed. Before this the lower branches reached almost to the ground.

It appears that the Sequoia can not be grown successfully in the northeastern United States. It has not proved hardy in New York City nor around Boston. Even trees that thrived for a number of years in Rochester were killed in the severe winter of 1917–18. It may be possible that there exists in the particular locality in which the Aurora tree is growing, a combination of soil and climate more favorable than in the other localities where the Sequoia has been unsuccessfully grown.

W. C. Muenscher
New York State College of Agriculture, Ithaca, N. Y.

Additions to the Flora of the Lake George Region

1 **Bromus tectorum** L. Along the state road, south of Whitehall, near the Barge canal locks at Comstock, this recently introduced grass was becoming common, June 20, 1920.

2 **Panicum calliphyllum** Ashe. A few plants of this grass were discovered on July 7, 1918, on the thin rocky slopes of Peaked mountain. The type locality for the species is Watkins Glen, and according to Mrs Agnes Chase, this is the second station for it in this State.

3 **Panicum philadelphicum** Bernh. Specimens of this grass, related to the common Panicum capillare, were collected on September 15, 1918, in a sandy hilltop field, south of West Fort Ann, and determined by Mrs Chase.

4 **Hippuris vulgaris** L. This rather uncommon water plant was discovered by Frank Dobbin on August 21, 1921, in the Battenkill river at Shushan.

5 **Chimaphila maculata** (L.) Pursh. Three small plants, not in flower, were discovered north of Hudson Falls, July 29, 1915. The upper midrib of each leaf was variegated with white. I suspect that this is the northernmost station for the spotted wintergreen in the Hudson valley, where it is replaced almost entirely by the common Prince's pine, Chimaphila umbellata. I have no other record of its growing in the Lake George region, and I have never collected it in the vicinity of Albany.

6 **Silene dichotoma** Ehrh. Plants of this recently introduced species were first found in a newly seeded meadow near Vaughns, north of Hudson Falls, June 30, 1913. It was afterward found in

a meadow southwest of Tripoli, and June 25, 1920, several plants in the sandy, gravelly field north of Tripoli cemetery. Frank Dobbin found it in a meadow at Shushan, July 14, 1920, suspecting it to be introduced with grass seed bought in Chicago.

7 **Amelanchier Bartramiana** (Tausch) Roem. Found by Frank Dobbin in Rich's swamp, southwest of Shushan, in flower on May 7, 1916, and additional numbers found deeper in the same swamp on May 27, 1917.

S. H. Burnham
New York State College of Agriculture, Ithaca, N. Y.

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New York State Museum

TWENTY-FIRST REPORT OF THE DIRECTOR OF THE STATE MUSEUM AND SCIENCE DEPARTMENT

INCLUDING THE SEVENTY-EIGHTH REPORT OF THE STATE MUSEUM, THE FORTY-FOURTH REPORT OF THE STATE GEOLOGIST AND THE REPORT OF THE STATE PALEONTOLOGIST FOR 1925

ALBANY

THE UNIVERSITY OF THE STATE OF NEW YORK

1926

M215r-Ja26-1000

The University of the State of New York

The State Museum, January 14, 1926

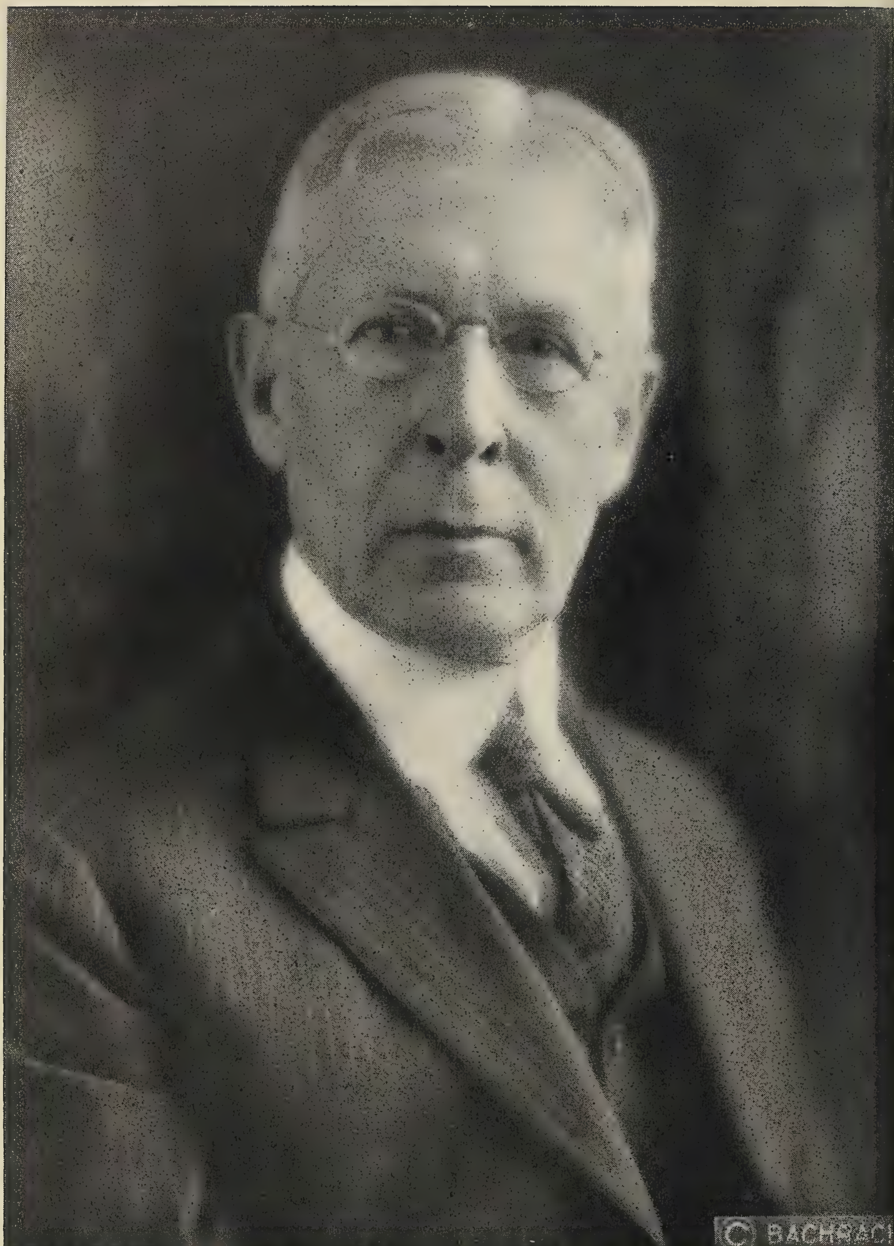
The Honorable Frank P. Graves
President of the University

SIR: I beg to submit herewith the report of the Director of the State Museum for the year 1925.

Very respectfully

JACOB VAN DELOO

Acting Director



John M. Clarke

New York State Museum Bulletin

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New York State Museum

TWENTY-FIRST REPORT OF THE DIRECTOR OF THE STATE MUSEUM AND SCIENCE DEPARTMENT

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IN MEMORIAM

John Mason Clarke

1857–1925

On May 29, 1925, after a brief illness, our former Director, Dr John Mason Clarke, passed away in the 69th year of his life. Doctor Clarke came of old American stock, with the best of traditions. He was born in Canandaigua, N. Y., on April 15, 1857, among the Devonian rocks which had a strong influence in shaping his later career as a scientist. His father, Noah Turner Clarke, was for 50 years teacher and principal in the academy at Canandaigua, and it was from his father that he obtained his first geology in school, as well as his classical training.

Doctor Clarke went to Amherst in 1873, where he studied under that inspiring teacher, B. K. Emerson. After his graduation from Amherst in 1877, he taught for 2 years in the Canandaigua Academy and then returned to Amherst as assistant to Emerson in 1879–80. He taught in the Utica Free Academy during the school year 1880-81. For the following year, through the efforts of Emerson, he was given an appointment at Smith College as teacher of geology and mineralogy—a position which he held until the end of the college year 1883 when he was given leave of absence to study for the doctorate at Göttingen, under Professor von Koenen. He returned to Smith College in the fall of 1884, and in the spring of 1885

became lecturer in geology, zoology and German at the Massachusetts Agricultural College. The following few months of unemployment were spent at Canandaigua, where he continued his work on the Upper Devonian.

Doctor Clarke's connection with the Geological Survey of New York began January 2, 1886, when he started work under James Hall. He gradually rose in position, and upon the death of Doctor Hall in 1898, succeeded him as State Paleontologist. In 1904, when Doctor Merrill retired, Doctor Clarke also became State Geologist and Director of the State Museum and Science Division of the Education Department; and he held these three titles until his death. In nearly 40 years of service he produced more than 200 scientific papers that won for him a place among the leading scientists of the world; and in the past 15 years, with the support of his scientific staff, he built up a Natural History Museum noted for its unusual character, originality and educational value.

Several memorials to Doctor Clarke have already appeared and a very full account of his life and works has been written for the Bulletin of the Geological Society of America by Professor Charles Schuchert of Yale University. It is the intention here, therefore, to touch upon Doctor Clarke more especially in his capacity of Director, State Geologist and State Paleontologist.

It was always Doctor Clarke's conviction that a museum which is not changing and growing is a dead museum. As Director he expanded the museum and moved it into the Education Building where there was more adequate space for exhibition. He was very successful in securing able assistants through whose work has grown up an entirely new archeological exhibit, a fine zoological exhibit, an enlarged mineralogical exhibit, an entirely new geological exhibit and a much enlarged paleontological exhibit with many restorations. Doctor Clarke was also unusually successful in obtaining gifts of materials or of large sums of money for creating exhibits. Notable among these important additions to the Museum, without great expense to the State, are the Indian groups with the accompanying decorated panels and lunettes, the gift of the late Mrs F. F. Thompson; a valuable collection of western Indian basket work, also the gift of Mrs Thompson; a large and very fine collection of bird eggs and a collection of starfish, presented by Benjamin W. Arnold; the Louis Agassiz Fuertes paintings of the birds of New York, donated by Mrs Russell Sage; the Thompson-Seton wash drawings of birds; the Peck memorial mushroom group; the Temple Hill mastodon, the gift of the late Emerson McMillin; and the fossil

sponge restoration group given by Mrs Higgins in memory of her husband, Governor Higgins.

Doctor Clarke's ambition, as the crowning achievement of his directorship, was the expansion of the Museum still further through securing a new museum building which would be a museum of art and history as well as of science. Much time and effort were expended in an attempt to secure the Roosevelt Memorial for a State Museum; and even when he met with failure he continued with his plans and undoubtedly would have seen the realization of his hopes were it not for his sudden and untimely death.

Doctor Clarke was interested in the various branches of science and was ready to give his support to all of them fully as much as to his own special field. As Director of the Museum he was ever industrious in securing means for the publication of large works on natural science, particularly those which would appeal to and draw the interest of the public. In this category belong the well-known Birds of New York by E. H. Eaton, in two large quarto volumes, with separate editions of the 106 colored plates, and the Wild Flowers of New York by H. D. House, also in two large quarto volumes, with a separate edition of the 264 colored plates.

In his capacity as Director, Doctor Clarke was also interested in and took steps for the preservation of natural monuments of the State. It is due to his efforts that we have the Clark Reservation at Jamesville; the Chittenango Falls Park at Cazenovia; Lester Park near Saratoga, and Stark's Knob monument at Schuylerville, under the supervision of the State Museum; and the John Boyd Thacher Park in the Indian Ladder region of the Helderbergs, under state control—all natural monuments and all obtained as gifts. Doctor Clarke even went outside the State in his efforts to preserve natural monuments and to protect wild life.

As State Geologist Doctor Clarke furthered the geological mapping of the State with the result that about two-thirds of the State has been mapped by geological experts at very small cost, many of the maps having been made by college professors during summer vacations. The New York State Survey has probably employed more college professors than any other state survey; and they have likewise been employed in the working out of the glacial geology of the State and also the economic geology—notably in connection with the salt, iron, oil and gas interests. Doctor Clarke is probably the only State Geologist who has favored equally both economic and purely scientific work. In this regard he fully maintained the traditional attitude of the New York State Survey which he inherited from Dr James Hall.

Paleontology was Doctor Clarke's special field as it had been Hall's. The surroundings in which he was born drew his attention in his early years to the Devonian formations, and he finally became the first authority in America on the Devonian. His most important work in this field was done in the last volumes of the Paleontology of New York, by Hall and Clarke—those describing the Trilobites of the Devonian and the Brachiopods. It is also due to his efforts that the Devonian rocks of New York have been, in a most refined manner, divided into their different beds and mapped in detail. Much of this work was carried out by his boyhood and life-long friend, the late D. Dana Luther, who was also one of Hall's field men. In later years Doctor Clarke found a wonderful field of geological activity in the Devonian of the Gaspé coast of Canada.

In the last decade of his life he was more inclined to look for the general, philosophic aspect of science, as shown by his work on Dependent Life, and to be retrospective in biographical and other literary work. The Life of James Hall, which is really a history of the geology of America during Hall's life, is the outstanding work of that kind. He also became interested in ceramics, particularly of New York, in the culture of the Pennsylvania Dutch of the earlier years and in other lines which amounted to hobbies, but which he treated in a scientific manner and about which he published treatises. He therefore possessed more scientific interests than most modern scholars, and as a result his publications of books and pamphlets not only were large in number but also embraced a great variety of subjects.[1]

Doctor Clarke had an unusually brilliant, well-trained mind. He worked hard and quickly and at the same time with such an ease of manner that he turned out a large amount of work apparently without effort; and he had likewise the ability to carry on several lines of work at the same time without confusion. Besides his keen, philosophical mind he was gifted with a strong artistic sense and a love of nature, evidences of which are seen in his writings and all through his life. He had many lovable qualities and was a man of such wide interests that he could be a most charming companion and friend. Strong in his likes and dislikes, he was at the same time a man of deeper sympathies than those who met him casually could realize, especially toward those who might be considered

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[1] A complete list of Doctor Clarke's publications may be found with Professor Schuchert's memorial of Doctor Clarke in the first number of the Bulletin of the Geological Society of America for 1926.

among the weak; and it was this which sometimes led him into being imposed upon. He was a friend to young people and many a young scientist has him to thank for a helping hand.

Honors came naturally to crown a lifetime of successful work, even up to the very end. The Thompson Gold Medal of the National Academy of Sciences was received shortly before his last illness, and death alone, according to letters from Professor Barrois, prevented his election to fellowship in the French Academy. He was elected to membership in numerous scientific and historical societies in this country, Canada, England, Germany, France and Russia; he was made a member of the National Academy of Sciences in 1909; elected vice president of the Geological Society of America in the same year, and president in 1916; made first president of the Paleontological Society in 1909; awarded the Prix de Léonide Spindiaroff by the International Geological Congress in 1910 for his geologic work in Gaspé; awarded a gold medal by the Permanent Wild Life Protection Fund in 1920, the Hayden gold medal of the Philadelphia Academy of Natural Sciences in 1908, and the Thompson Gold Medal of the National Academy of Sciences in 1925. He received an honorary Ph. D. degree from the University of Marburg in 1898, that of D. Sc. from Colgate University in 1909, University of Chicago in 1916 and Princeton University in 1919, that of LL. D. from Amherst College in 1902 and from Johns Hopkins University in 1915.

THE MUSEUM

General. The work of this department, both research and museum, has been continued along established lines, with such changes as new conditions or circumstances required.

New material and new exhibits have been added to the Museum. Notable among them is a display of live animals in Zoology Hall, including a number of snakes of various species, several salamanders and turtles. Facilities of the Museum are inadequate for extensive exhibition of live animals. Two new exhibits have been added to Paleontology Hall. The paleobotanical restoration of the Gilboa Fossil Trees, one of the largest and most striking restorations attempted here or elsewhere, was opened to the public on February 12, 1925, after 2 years of laborious and ingenious work. This group and a new case entitled: "What is a Geological Formation?" are described in a paper on New Museum Exhibits which follows in this report. The case, "What is a Geological Formation?" was designed as a companion to the "What is a Fossil?" case which was installed in the Museum some time ago and which has proved to be exceedingly successful. Lack of space remains the most outstanding obstacle to the progress of Museum exhibitions and therefore will be a grave hindrance to the Museum in its policy of introducing educational exhibition cases to give to the numerous unscientific visitors an adequate background for a better understanding and appreciation of the various exhibits.

Unexhibited collections. The Museum continues to be hampered by the fact that important collections, through lack of space, remain stored away in various places in the Education Building where they are inaccessible to visitors or students. This is particularly true of the entire collections of the recent Mollusca of New York and elsewhere. Students of the Mollusca have come to the Museum with the express purpose of studying parts of this collection, and the Zoologist has been forced to refuse their requests. Collection after collection of paleontological and stratigraphical material has been packed away in boxes, which makes the material practically inaccessible or involves a laborious amount of work to obtain perhaps a few specimens for exchange or for study by our staff or outside scientists. A museum should be able to keep all collections obtained in tiers of drawers arranged systematically so that they are immediately accessible.

Parks. The State parks under the custody of the New York State Museum were cited in the preceding report but no definition of

them was given. It has been thought advisable to list them, giving a description of their nature and size and the conditions under which they were acquired.

Chittenango Falls Park. Located 4 miles below Cazenovia, Madison county. Contains a gorge and waterfall over 100 feet high. Interesting cliffs of Devonian and Silurian rock formations. Abundant flora with rare ferns. Interesting alike for its scientific and scenic features. Recreational facilities are being provided and plans have been drawn for a new state highway to pass through the gorge, thus making available in the best possible way the scenic beauties of the place. Area 22 acres. Acquired by gift in 1922 from the Chittenango Falls Park Association.

Clark Reservation. Located in the town of De Witt about 6 miles from Syracuse. This is a glacial park consisting of 115 acres and was the gift of Mrs Frederick Ferris Thompson. The origin of its main features is due to the great glacial streams which passed along the ice front during the retreat of the continental glacier. The park contains a number of abandoned cataracts and plunge basins, the largest of which fully equals in size those at Niagara Falls. A lake having an area of 7 acres occupies one of the plunge basins. The park is visited by many thousands annually.

Lester Park or "Cryptozoon Ledge." Located in the town of Greenfield, 3 miles west of Saratoga Springs. The area is 3 acres and the park is crossed by a highway at its most interesting spot. The main feature is the "Cryptozoon Ledge," a broad, flat glaciated platform of Cambrian limestone filled with crowded remains of some of the earliest marine plants, known as Cryptozoons. The Cryptozoons grew in large, round, concentric masses and appear like gigantic cabbage heads. The planing action of glacial ice and later weathering have resulted in making this exhibit truly unique. The park, which was acquired solely for the purpose of preserving this remarkable ledge, is the gift of Willard Lester of Saratoga Springs.

Stark's Knob. This reservation of 4 acres is at the north end of the Saratoga battlefield 2 miles above Schuylerville and close to the state highway. The knob is the remains of a volcanic plug or neck and the only one known in the State. Previous to its acquisition some quarrying operations had been in progress. The knob also possesses a historic interest. It was here that General John Stark mounted his battery and effectively obstructed attempts of the defeated Burgoyne to withdraw his forces northward through the narrow valleys of the Hudson and the Battenkill. Stark's Knob is the gift of the late Emerson McMillin.

Squaw Island. This is a small island opposite Sucker brook near the north end of Canandaigua lake, Ontario county. Squaw island is so called on account of the tradition that during Sullivan's raid in 1779, the Seneca women from the Indian village at the foot of the lake took refuge there. The island is interesting geologically because of the formation of "water biscuits" found abundantly on the beaches and lake bottom adjacent to the island. The "water biscuits" are oval in shape and their origin is due to the waters charged with lime and carbonic acid gas from Sucker brook, coming in contact with living algae. Absorption of the carbonic acid gas by the algae results in the deposition of the lime on the object where the algae are growing, and as the process is repeated the "water biscuit" is gradually built, consisting of a network of algae with concentric layers of lime. Custody of the island was taken over by the State Museum in 1918, and through the generosity of the late Mrs Frederick F. Thompson of Canandaigua, a tablet explanatory of its geological and historical interest has been erected.

Publications. During the past year the following publications have been issued:

Bulletin 256 The Susquehanna River in New York and Evolution of Western New York Drainage; by Herman L. Fairchild

Bulletin 257 Key to Gall Midges; by Ephraim P. Felt

Bulletin 258 The Utica and Lorraine Formations of New York. Part I. Stratigraphy; by Rudolf Ruedemann

Bulletin 259 Geology of the Gouverneur Quadrangle; by H. P. Cushing

Bulletin 260 Twentieth Report of the Director of the State Museum and Science Department (1924)

Bulletin 261 Geology of the Ausable Quadrangle; by James F. Kemp and Harold L. Alling

Bulletin 262 The Utica and Lorraine Formations of New York, Part II. Systematic Paleontology; by Rudolf Ruedemann

Bulletin 263 Albany Molding Sands of the Hudson Valley; by Charles M. Nevin

Bulletin 264 Studies in New York Spiders (Genera: Ceratinella and Ceraticelus); by C. R. Crosby and Sherman C. Bishop

Bulletin 265 Some Silurian (Ontarian) Faunas of New York; by Rudolf Ruedemann

Bulletin 266 Report of the State Botanist for 1924

Lectures. The Museum has continued its policy of giving a series of free public lectures which are untechnical and on subjects of general and popular interest.

Field work. Professor R. J. Colony of Columbia University has continued his work on the Schunemunk quadrangle, and Dr Robert Balk, also of Columbia University, has been doing geological mapping on the Newcomb quadrangle.

The results of the field investigations in oil and gas by Professor Henry Leighton and Professor R. E. Somers, both of the University of Pittsburgh, and the investigations of Charles M. Nevin of Cornell University on molding sands, are included in the report of the Assistant State Geologist. The work of mapping the four quadrangles of the capital district was continued this past summer by the Assistant State Paleontologist, and smaller collecting trips were made by both the Assistant State Paleontologist and the Paleobotanist.

Field expeditions and gifts have materially increased the collections in the divisions of zoology and entomology. The results of the field work on New York mammals in 1925 by Dr Francis Harper, secretary of the Boston Society of Natural History, are given in the report of the Zoologist. Considerable additions have been made to the botanical collections through contributions and collections by the State Botanist and others.

Legislative support and loss of staff. In spite of the fact that the Museum fills a great educational need of the public and that the people from within the State and tourists in large numbers have made generous use of the advantages offered, the State Museum still lacks adequate legislative support. The salaries paid to the staff of the Museum are inadequate and therefore expert members of the Museum staff are constantly leaving their positions in search of something that will guarantee a reasonable return for their services. We have in the last few years lost an Assistant State Geologist, the Assistant in Economic Geology, Mineralogist, and Archeologist. The position in economic geology has never been filled. Our former Mineralogist left for a position with the American Museum paying more than twice the salary he was receiving with the State Museum, and at the same time our Museum could offer him an increase of only $100 a year if he stayed. Twice the Museum has tried to fill the position, and we are now without a Mineralogist because only an untrained man just out of college would accept such an inadequate salary. We have also lost the position of scientific technician. The State Entomologist and State Botanist have both for years had a crying need for an assistant but they have been forced to do without or to use temporary and unskilled help at intervals. This makes an added burden for men who are already most inadequately paid for the services required

by their position. Just recently the Museum has likewise lost a trained mechanic, the lack of whose services considerably hampers the department. At the time of writing there is no prospect of filling the position at the salary provided.

The Director of the State Museum died on May 29, 1925. The requisites of the position are so out of proportion to the compensation that the position still remains vacant, although about 8 months have passed since his death. All this certainly shows either indifference or a lack of comprehension of the value of scientific service to the State.

STAFF OF THE DEPARTMENT OF SCIENCE

The members of the staff, permanent and temporary, of the Department as at present constituted, are:

ADMINISTRATION

John M. Clarke[1], Director
Jacob Van Deloo, Clerk and Secretary of the Museum
Anna M. Tolhurst, Director's Stenographer

GEOLOGY AND PALEONTOLOGY

John M. Clarke,[1] State Geologist and State Paleontologist
Rudolf Ruedemann, Assistant State Paleontologist; Curator of Paleontology
Chris A. Hartnagel, Assistant State Geologist; Curator of Geology
William L. Bryant, Honorary Curator of Fossil Fishes
Winifred Goldring, Paleobotanist
Edwin J. Stein, Draftsman
Marie F. Tetrault, Stenographer
Charles P. Heidenrich, General Mechanical Assistant
Marion E. Bollman, Clerk
John L. Casey, Custodian of Museum Collections
William Rausch, Cabinetmaker
Ernest S. Teetsel, Laborer
James S. Skinner, Laborer

Temporary Experts

Areal Geology

Dr Robert Balk, Columbia University
Dr R. J. Colony, Columbia University

[1] Died May 29, 1925.

Economic Geology

Professor Henry Leighton, University of Pittsburgh
Professor R. E. Somers, University of Pittsburgh
Mr Charles M. Nevin, Cornell University

Paleontology

S. K. Roy, University of Illinois
J. J. Wirz, Rochester

BOTANY

Homer D. House, State Botanist

Temporary Expert

Clair A. Brown, Syracuse University

ENTOMOLOGY

Ephraim P. Felt, State Entomologist
Douglas B. Young,[2] Assistant State Entomologist
Elma Rose Atamian, Stenographer
Anna J. De Meur, Clerk

ZOOLOGY

Sherman C. Bishop, Zoologist
Benjamin W. Arnold, Honorary Curator of Ornithology
Walter J. Schoonmaker, Technical Assistant
Arthur Paladin, Taxidermist

Temporary Expert

Francis Harper, Boston Society of Natural History

ARCHEOLOGY

Noah T. Clarke, Archeologist
Harry C. Wardell, Technical Assistant

ACCESSIONS

Paleontology and Paleobotany

By Donation

Frank Bulman, South Kensington, London
Preparation of Dictyonema flabelliforme, Shineton shale, Cherme's Dingle, near Wrekin, Shropshire, England

Dr S. L. Powers, chief geologist, Amerada Petroleum Corp., Tulsa, Okla.
Slab with Climacograptus colonies. Athens shale, Catawba Valley, Virginia

[2]Died April 5, 1926.

Frederick H. Allen, New York City
Large specimen of *Cryptozoon undulatum.* Theresa Limestone, Saratoga, N. Y.
G. Arthur Cooper, Hamilton, N. Y.
Twenty specimens of two new species of Crinoids, from Hamilton shale, Hamilton, N. Y.
Dr F. W. Sardeson, Minneapolis, Minn.
Fifteen specimens, *Plectambonites sericius* (Soby), Tecorah shale, St Paul, Minn.
Fourteen specimens, *P. minnesotensis* (Sard.), Galena limestone, St Paul, Minn.
G. S. Bixby, Plattsburg, N. Y.
Two hundred miscellaneous specimens of fossils and minerals from various localities
R. W. Gausmann, division engineer with New York City Board of Water Supply, Grand Gorge, N. Y.
Fossil stump of seed fern, Upper Devonian, Gilboa
New York City Board of Water Supply
Various fossil plant specimens, Gilboa, N. Y.
Luther E. Dennis, superintendent with Hugh Nawn Construction Co., Gilboa, N. Y.
Two specimens of a new species of fossil tree, Upper Devonian beds, Gilboa

By Purchase

E. Reinhard, Buffalo, N. Y.
Sixteen specimens of Bertie Waterlime fossils, at Buffalo, N. Y.

Geology and Mineralogy

By Donation

Whitehead Brothers Company, Rochester, N. Y.
Molding sand exhibit showing various grades of sand. The exhibit includes upper and lower halves of mold together with rough and finished castings.
Professor W. G. Foye, Middletown, Conn.
Minerals from Connecticut: thulite, Haddam; uraninite crystals, Portland; green tourmaline on quartz, Collins Hill, Portland; iolite, Hungry Hill, Guilford; beryl, Collins Hill, Portland
Mrs W. J. Bennett, Lake Mahopac
Epidote in quartz
Edwin C. Dinturff, Syracuse, N. Y.
A suite of dike rocks from Syracuse, Ithaca, Kentucky, South Africa and Arkansas. Also a specimen of selenite from Fayetteville, N. Y.
W. W. Jones, Albany
Argentite from "Annie Mine," Black Hawk, Col.
A. G. Betts, Kinderhook
Celestite, Schoharie, N. Y.
Bernard O'Brien, Herkimer
Quartz from "box-vein," Lyonsdale
Richard Welcying, Schenectady, N. Y.
Specimen of native copper found in drift at Schenectady
New York Trap Rock Corporation, Verplanck, N. Y.
Close fold in Precambrian limestone from quarry at Verplanck, N. Y.
E. W. Leavenworth, Carlisle, N. Y.
Clay concretion in limestone found near Carlisle

By Purchase

E. S. Law, Charlemont, Mass.
Large specimen containing many crystals of ankerite; one large specimen actinolite

Historical Objects

By Donation

Fred Woodruff, Warwick

Cast iron plow having one wooden handle. On one side of the beam is this inscription: "St. John Malver & Co."; on the other: "Kerr No. 1."

Peter C. Brooks, Cornwall

Dog power. A wooden tread power with iron fly wheel. A churn with top and the sweep used with the power were also received.

Entomology

Additions to species of mosquitoes or Culicidae by exchange, from Eric Hearle of the Entomological Laboratory, Vernon, B. C., and by gift from Dr William Matheson of Cornell University:

Excellent series of birch leaf miner, Fenella pumila Klug., and elm leaf miner, Kaliofenusa ulmi Sund., by collection.

Large series of spruce leaf miner, Olethreutes abietana Fern. Reared from infested material.

Number of other desirable additions to the collections through field work, contribution and exchange.

Zoology

By Donation

Reptiles and Batrachians

Leslie Karner, De Freestville
Garter snake, De Freestville

Paul McNamee, Loudonville
Hog-nosed snake, Loudonville

James J. Corrigan, Albany
Two pond turtles, near Saratoga

S. W. Frost, Arendtsville, Pa.
Fence swift, Arendtsville, Pa.

Jay H. Weber, Leonia, N. J.
Hog-nosed snake, Jones Beach, Long Island

G. P. Englehardt, Brooklyn
Newt, Syosset, Long Island
Cricket frog, twelve specimens, Long Island

Alf Dampf, Mexico City
Three salamanders, Mexico City

L. M. Klauber, San Diego, Calif.
Two red diamond rattlesnakes
Three Boyle's king snakes
Two Pacific rattlesnakes
Two pallid rattlesnakes
Two California king snakes

C. S. Brimley, Raleigh, N. C.
Numerous specimens of salamanders

Richard Brown, Port Allegany, Pa.
Many salamanders

Claire Brown, Albany, N. Y.
Musk turtle, Burden's lake, Rensselaer county.

Dr W. Klinglehoffer, Germany
Salamanders

M. K. Brady, Washington, D. C.
Salamanders and lizards

Birds

Dr Addison Miller, East Schodack
American egret, East Schodack

Fish

Carl Miller, Albany
Pickerel, Bacchus pond, Rensselaer county
State Conservation Commission, Albany
Frost fish
White fish
William L. Rathky, Albany
Bowfin, Lake Champlain

Mammals

Dr H. D. House, Albany
Star-nosed mole, Rafts pond, Albany
Leslie Karner, De Freestville
Brewer's mole, De Freestville
John L. Casey, Albany
Big brown bat, Albany
Arthur Kilfoil, Rensselaer
Woodchuck, Nassau
Sarah E. Veeder, Lyons
Horns of Roman ox (pairs)
Two African antelopes (pairs)
Geraldine Fitzgerald, Whitehall
Skull of woodchuck, Whitehall
D. B. Young, Albany
Brewer's mole, near Newport
H. P. Crisp, Albany
Red squirrel, Nassau
Edward J. MacCormack, Rensselaer
Two skunks, Tassawassa lake

Spiders

Fanny T. Hartman, Rockledge, Fla.
Thirty specimens
Mrs Mary Matiske, Albany
One specimen
E. J. Anderson, Cold Spring Harbor, L. I.
One specimen
C. R. Crosby, Ithaca
Specimens from Coxsackie, several vials
R. Hancock, Birmingham, England.
Six specimens aquatic species
Dr H. D. House, Albany
Several vials
D. B. Young, Albany
Several vials
C. A. Hartnagel, Slingerlands
Several vials
Winifred Goldring, Slingerlands
Several vials
Jacob Van Deloo, Albany
Several vials

By Collection

Reptiles and Batrachians

Dr S. C. Bishop
Garter snake, Avalanche lake, Essex county
Newt, Chapel pond, Essex county
Wood frog, Thacher Park, Albany county
Three dusky salamanders, Thacher Park, Albany county
Three timber rattlesnakes, Honeoye lake
W. J. Schoonmaker
Newt, Syosset, L. I.
Musk turtle, Burden's lake, Rensselaer county

Fish

W. J. Schoonmaker
Pickerel, Burden's lake, Rensselaer county

Mammals

Dr S. C. Bishop
Racoon, Stamford
W. J. Schoonmaker
Four deer mice, Galway
Deer mouse, Rensselaer
Three House mice, Rensselaer
Short-tailed shrew, Rensselaer
Woodchuck, De Freestville
Two cottontail rabbit skulls, East Nassau
Two skunks, Tassawassa lake
Dr Francis Harper
Large collection

Spiders

Dr S. C. Bishop
Collections from Voorheesville; Bolton Landing, Lake George; Dunwoodie; New Salem; McLean; Clarksville; Intervale; Chapel pond, Essex county, and Adirondack Lodge
W. J. Schoonmaker
Several vials from Rensselaer county

By Exchange

Reptiles and Batrachians

L. S. Frierson jr, Gayle, La.
Four blue-tailed skinks
Five striped lizards
Snapping turtle
Spotted chicken snake
Copperhead snake
Holbrook's king snake

By Purchase

Paul A. Webb, Meadville, Pa.
Two mudpuppies, Meadville, Pa.
Fifteen mudpuppies, French creek, near Saegertown, Pa.

Botany

By Donation

The Dr J. V. Haberer Collection
Ten thousand specimens
The Martha C. Carter Collection
Four hundred specimens
W. C. Ferguson, Hempstead
One hundred specimens
C. A. Brown, Albany
Eighty-five specimens
Mrs O. P. Phelps, Gansevoort
Ten specimens
Mrs Franc F. Pugsley, Pittsford
Seven specimens

By Exchange

Gray Herbarium, Cambridge, Mass.
One hundred one specimens
Elam Bartholomew, Stockton, Kans.
Two hundred specimens

Other specimens have been contributed by a number of correspondents. Collections by the State Botanist and his temporary assistant have added 1280 specimens to the herbarium.

ADDITIONAL RECORDS OF PLEISTOCENE MAMMALS

Since the publication in 1922 of New York State Museum Bulletin 241–42 on The Mastodons, Mammoths and Other Pleistocene Mammals of New York State, by C. A. Hartnagel and Sherman C. Bishop, the following additional records have come to the attention of the authors.

Fulton County

1 1853. Rangifer sp. Caribou. "In the collections of the Portland Society of Natural History, at Portland, Maine, is a horn of a caribou, rather recently presented, together with other objects, by daughters of the late Maj. Charles Harrod Boyd. The specimen bears these data: "Carabou horn from swamp six feet below surface — E. Bartlett — Rockwood — Fairytown — N. Y.— 1853."

"The antler, which is from the right side of the head, is attached to the parietal bone and bears but one branch which leaves the main shaft 4½ inches above the burr. The tips of both the main shaft and the branch are broken off. The chord of the main shaft from the burr measures 23½ inches and has a diameter of 1¼ inches just above the branch; the branch measured from the front of the main shaft along its lower surface has a length of 8 inches and is nearly uniform in diameter for its entire remaining length."

The above account is taken from an article by Arthur H. Norton, Museum of Natural History, Portland, Maine, published in Journal of Mammalogy, May 1924, p. 132–33. Rockwood has an elevation of 1044 feet and is in the town of Ephratah.

Madison County

2 1842 (before). *Woodstock.* "In the yellow-colored clay which underlies the swamp back of the village of Woodstock in Madison county, the soil of which is muck or peat, the tooth of an elephant, the Elephas ...., was found in digging a ditch. Attention to this discovery was directed by Mr Gerrit Smith and the Rev. Mr Schofield of Peterboro, from whom fragments were received, the tooth having separated into parts by exposure to the air and rough usage. This is the only fossil which was seen, forming a part of the quaternary era, during the survey of the district. A part of the tooth is in the State Collection." Lardner Vanuxem, Natural History of New York, Geology, Part III, 1842, p. 220. Among the Museum collections are a number of unlabeled fragments of mammoth teeth but none of the mastodon. It seems likely therefore from this fact and from the brief account given by Vanuxem that the tooth found was that of the mammoth.

Steuben County

3 1853 (before). *Mitchellville.* Mastodon or Mammoth. In the History of the Settlement of Steuben County, New York, by Guy H. McMaster, published 1853, is the statement (page 8) that "the tooth of a mammoth was once found under the bed of one of our central mill-ponds." On page 11 of the same publication is a note which reads:

The mastodon's tooth alluded to above was dug from a bed of blue clay near the steam saw-mill of Mr George Mitchell, in the Gulf road between Bath and Wheeler. It is eight or ten inches in length. A large bone was disinterred at the same place which crumbled on exposure to the air. Further examination will doubtless disclose other grinders of this huge beast and perhaps a pair of those broad tusks, curving outwardly at the points, somewhat like scythes, which adorn the heads of its brethren found elsewhere, and with which one good able bodied fellow, sweeping his head to and fro in wrath, might mow down an army of antagonists like meadow grass.

The bed of clay in which the tooth was found is of unusual depth and tenacity, and it is guessed that the animal of which the said bone was an appurtenance while rambling through the gulf, indiscreetly bounced into the mire and was unable to disengage his ponderous feet. It is further surmised that the bears may have pulled his skull around after death but that the frame of his body remains where he mired.

The writers are indebted to the Honorable Reuben B. Oldfield of Bath, N. Y., for calling attention to the published account in McMaster's history. What became of the tooth is not definitely known. In a letter Mr Oldfield states that "it might have been in the high school building which burned about that time." As the published account refers to the find as "the tooth of a mammoth" and also as "the mastodon's tooth," it is impossible to decide to which animal the tooth belonged. In view of the conditions where the tooth was found and the other finds recorded from Steuben county the chances are that the tooth belonged to the mastodon.

Orange County

4 1925. *Monroe.* Mastodon. Three well-preserved teeth and a few bone fragments were discovered October 16, 1925, by workmen engaged in cleaning out a spring on the property of the Orange and Rockland Electric Company of Monroe, N. Y. The attention of R. W. Smith, president of the company, having been directed to the find, steps were immediately taken to make a careful survey of the ground in the immediate vicinity in the hope of securing addi-

tional remains. Excavations were confined to a rather limited area by the character of the ground but in the course of a few days a large tusk was exposed which had a length of about 6½ feet and a diameter at the base of about 8 inches. The tusk was in such a friable condition that expert handling was required to remove it intact. When fully exposed it was photographed in position in the ground. It was then given a protective coat of plaster of Paris and sent to the American Museum, New York City.

The exact position of the spring may be located on a United States Geological Survey map, Schunemunk quadrangle, by continuing a line due east from Oxford Depot, on the Erie Railroad, until it intersects the first stream which flows northward into Moodna creek. In other words, the spring lies 1 mile east of Oxford Depot, 1 mile south of Bull Mine and about 1½ miles north and a little west of Monroe. A photograph of the teeth and a brief account of the discovery of the remains was given in the New York Herald Tribune for Friday, October 23, 1925, p. 14.

New York County

5 1925. Mastodon. Remains of a mastodon were unearthed in late April 1925 by contractors excavating for the foundations of an apartment house north of Dyckman street near Seaman avenue, New York City. An account of the discovery was given by H. F. Osborn and Charles C. Mook in the New York Herald Tribune and reprinted with several photographs and maps, in the Literary Digest for May 9, 1925, p. 25. The following account is taken from that of Osborn and Mook:

The remains consist of both sides of the lower jaw, fairly well preserved, but with the articular processes missing, and some fragments of limb bones, including part of the humerus, or upper arm bone. Several teeth, which had been excavated with the bones, were missing, having been taken away by bystanders. Two of these teeth have since been brought to the Museum, and it is hoped that more will appear. The teeth now included in the specimen are the third milk molar of the left side, and the first molar and a fragment of the second molar of the right side.

Erie County

6 1925. Bison. The discovery on December 31, 1925, of bison remains in the city of Buffalo has revived interest in the controversy regarding the origin of the city's name. Evidence of the former occurrence of the bison in western New York is to be found in the records of remains from Jamestown near the outlet of Chautauqua

lake and in the refuse pits on the sites of Indian encampments or villages on Cattaraugus creek and at Irving, but so far as our records show, this is the first discovery of remains within the actual limits of the city itself.

These remains are probably not to be regarded as fossil but they are interesting in the evidence that they provide for the historical basis of the name of the city and creek.

The facts on which the following account of the discovery is based have been supplied by William P. Alexander of the Buffalo Society of Natural Sciences, in whose care the bones have been placed. The bones were unearthed by workmen employed by the city in the construction of a sewer trench on the Old Terrace, now one of the busy thoroughfares of the city. The attention of the society was directed to the find by G. O. Curtis of Buffalo who recognized the possible importance of the discovery and delivered a number of the bones to the museum. Mr Alexander immediately visited the site of the excavations and made a careful survey of the deposits. The trench had been refilled at the exact point where the bones were found but 20 feet eastward the section showed that the trench had been cut through a layer of dry, yellow stratified sand, a deposit built up as part of the delta of Little Buffalo creek. Assistant City Engineer John H. Feigel, who was present when the fragments were thrown out, is responsible for the statement that the bones were buried to a depth of about 8 feet.

A list of the bones recovered follows: parts of three crania; five single jaw bones with teeth; one tibia; one metacarpal; two metatarsals. Other bones in the north side of the trench were noticed by the workmen who failed to recognize the importance of the discovery and refilled the trench.

SOME PROBLEMS IN THE SCHUNEMUNK AREA

By R. J. Colony

One of the prominent structural zones in the Schunemunk quadrangle runs from the northeastern part of the area through the entire length of the quadrangle in a southwesterly direction, continuing through the adjacent region to the southwest. In this zone are included Snake hill, slightly southwest of the city of Newburgh, and a series of prominent isolated hills lying just west of Schunemunk mountain and closely adjoining it. The largest and most northerly of these is Woodcock hill, about 1 mile south of Salisbury Mills and just west of the northern end of Schunemunk, and the most southerly one is a much smaller hill about one mile east of Oxford Depot, which may be called, for convenience, Oxford Depot hill. Directly north of Oxford Depot hill is Bull Mine hill; northeast of Bull Mine hill and between it and Woodcock hill there are three other small hills; the most southerly of these is called Galloway hill, the most northerly is called Round Top and the third has no name. The structural zone along which these hills are distributed is more or less offset in places by crossfaults, particularly in the southern part of the quadrangle, just south of Oxford Depot hill; here the zone has been shifted to the west, and the structural conditions become more complex. This zone, as the writer has previously mentioned,[1] bifurcates at the north end of Schunemunk mountain and runs along the base of the mountain on both east and west sides, separating it from the Precambrian crystalline complex on the east and from the series of isolated hills just mentioned, on the west. All of these isolated hills, including Snake hill, are detached faulted portions of the main mass of Precambrian crystallines that occupies the southern and eastern portion of the quadrangle. Schunemunk mountain is also cut off on the south by structural breaks that are so badly obscured by a heavy cover of drift that their distribution and relations have not yet been exactly determined. It seems certain, however, that Schunemunk mountain, which is composed of more or less thinly bedded, flaggy Devonian graywacke (Bellvale flags) conformably overlain by a coarse conglomerate (Schunemunk conglomerate) that occupies the highest parts of the mountain, is a down-faulted block that is itself structurally complex, owing its position in part to folding and thrust faulting of Appalachian age and in

[1] Colony, R. J. Field work in the Schunemunk Region during 1924. Annual Report, Director of New York State Museum, 1924.

part to the later block-faulting that occurred during Triassic time, and owing its development as a physiographic feature to post Triassic differential erosion that etched out the older and softer Cambro-Ordovician sediments surrounding the more resistant and geologically younger rocks of which the down-dropped block is composed.

Snake hill and the other isolated hills on the west side of Schunemunk mountain are all remnants of the great overthrust crystalline mass from the east. They are all in fault-contact with the Hudson River slates along a curved and warped thrust-plane that dips in a southeasterly direction at angles varying from 35 to 60 degrees and that rises toward the southwest, so that the thrust contact between the gneiss and the Hudson River slates lies at a higher elevation on Bull Mine hill than it does on Woodcock and Snake hills to the northeast.

The western slopes of these detached hills of gneiss are very abrupt, whereas the eastern slopes are in general less steep, extending to level meadows that in the aggregate form the narrow valley between the hills of gneiss on the west and Schunemunk mountain on the east.

Involved with these gneiss hills on the east and underlying the meadows of the valley are Cambro-Ordovician and later sediments in complicated structural relationships, in general much obscured by heavy cover. This valley lies along a fault zone that is a product of dynamic conditions during Triassic time, so that the detached hills of gneiss were cut off from the main crystalline mass by normal faults that intersected the older thrust faults of Appalachian age, and they were separated and offset from one another by oblique faults that probably were closely related to the general Triassic disturbance and possibly represent the closing stages of that movement.

It is therefore evident that within the very restricted area beginning with Snake hill in the northeastern part of the quadrangle and extending southwesterly and embracing Schunemunk mountain and the narrow zone on either side of it there is a structurally complex belt, made up of formations extending from the Precambrian crystallines to Upper Devonian, that have been subjected to at least three, and possibly four, periods of profound deformation, provided it is conceded that the rocks of the area have passed through the Taconic movement as well.

Several thousand feet of sedimentary beds are represented, including the Wappinger limestone, the Hudson River slates, the

Shawangunk conglomerate, High Falls shale, the Helderbergian series, the Highland Mills beds and related formations, among which are representatives of the Coeymans, New Scotland, Port Ewen, Oriskany, Esopus and Schoharie formations; and very considerable thicknesses (300 feet?) of the Cornwall shales, Bellvale flags (3000 feet?) and Schunemunk conglomerate (700 feet?).

These sediments, folded during the Appalachian revolution and forming the extreme northern tip of the great syncline that extends southwesterly into New Jersey, were later very badly broken and displaced during Triassic block-faulting. As a result of this later movement the folded sediments now comprising Schunemunk mountain and its immediately adjacent narrow valley on either side were crowded by down-dropping into the narrow space between the massive crystallines on the east and the overthrust but broken margin of them on the west that was itself badly broken and dislocated by the same Triassic movement. Thus the strata forming Schunemunk mountain, originally synclinal, have been so badly crowded that on the eastern side and especially at the base of the mountain, they are vertical in attitude, exhibiting many crush-zones, excessive jointing, and slickensided and striated surfaces; that is, they show evidence of much intraformational crowding and movement. Toward the top of the mountain the dips become flatter but they are still steep. The north end of the mountain is split longitudinally by a fault that seems to die out towards the south, but this is not yet definitely established. At any rate, there is a swamp on the top of the mountain that lies between steep escarpments on either side of it, and the base of the conglomerate on the eastern side of this break is 200 feet higher in elevation than on the western side.

The severe dynamic conditions imposed on this narrow belt have been responsible for the development of minor areas especially complex that have proved puzzling to previous workers in this district, and have been the object of special attention during the brief periods of field work both in 1924 and this year. These areas are as follows: (1) north of the north end of Schunemunk, the so-called "Idlewild Syncline;" (2) the valley on the east side of Schunemunk, including the Highland Mills section; (3) the valley on the west side of Schunemunk, including the detached hills of crystalline rock, the relations here being extremely complex; (4) the region southwest of Monroe, between the main mass of the crystallines and the western limit of the quadrangle.

In all of these minor areas small remnants of the broken synclinal mass are involved with overthrusts of Appalachian age in

such a manner as to suggest that the original Appalachian folding was not productive of simple synclinal structures, but that there was connected with it some complex thrust faulting as well. It was to these areas that attention was more particularly directed; additional work will be necessary before the structural problems connected with them can be satisfactorily solved.

REPORT ON THE FIELD WORK DONE FOR THE NEW YORK STATE GEOLOGICAL SURVEY IN GEOLOGICAL MAPPING OF THE NEWCOMB QUADRANGLE, ESSEX COUNTY, N. Y.

By Robert Balk

The writer was engaged in geological mapping of the Newcomb quadrangle from July 1 to September 30, 1925. Field work was carried on without interruption during the whole time. The northern half of the quadrangle, which is situated in the Adirondack mountains, southwest of Mount Marcy, has been covered almost completely. The middle part of the southern half has not yet been studied.

Formations

Four general formations of rocks were mapped. They are:

1*a* Series of Precambrian crystalline rocks. A sedimentary series, usually called Grenville series, consisting of impure marble and containing crystals of yellow quartz and red garnet, black graphite and green diopside, and tourmaline of various colors. In places the marble is found associated with amphibolites and quartzites. The latter show sometimes slight development of pyrite, chalcopyrite and hematite in veinlets.

b An intrusive series of anorthosite, gabbro and a basic granite-syenite, (nordmarkite).

2 Basic dikes, younger than the first group, of unknown but possibly of Precambrian age.

3 Quaternary glacial (till) and postglacial deposits (fluvio-glacial sands).

4 Recent stream deposits and small accumulations of peat.

Distribution

The distribution of the rocks is as follows:

In its most northeastern corner the mapped area touches the great massif of anorthosite which constitutes the central part and the highest peaks of the Adirondack mountains. About 2 square miles are made up of this characteristic rock. Southwestward the large intrusive is fringed by a more basic, "rim-facies," that is, a rock richer in dark minerals (hornblende, augite, garnet), which has previously been described by many authorities. Farther southward or southwestward the general distribution of the Precambrian rocks suggests a systematic arrangement as the igneous rocks both

decrease in mass and grow more acidic and as, on the other hand, the Grenville sediments increase in mass. In other words, the igneous rocks immediately southwest of the massif of anorthosite are comparatively basic representatives (gabbro, syenitic granites, rich in plagioclase, augite and hornblende). They constitute almost the entire northern half of the sheet, with the exception of three tracks of marble—at Newcomb, Goodenow river valley and Chain Lakes—which represent perhaps huge inclusions.

Still farther to the south and southwest the gabbros decrease and within the basic granites more acidic phases and indistinctly bounded bands of a proper granite appear. Southward from the latitude of Cedar river the series of sedimentary rock becomes very conspicuous and equals in mass the intrusives which *in turn* grow still more acidic. A reddish-pink, medium-grained granite is particularly well developed.

The quaternary rocks—especially till—cover a considerable area of the sheet, although most of the morainic material has been removed from the higher mountain slopes, except some large boulders. The drift, however, covers much of the valley grounds as a continuous sheet. The Hudson, Goodenow, Cedar, Indian and Boreas rivers in postglacial time cut their beds into these soft deposits. They frequently reach the hard rock floor and show remnants of their former higher level in the form of cross-bedded sands along their courses, several feet higher than the present level.

Special attention was to be directed to the primary structures of the Precambrian rocks, which were originated during the time of the intrusion. It was found that the basic rim-facies of the anorthosite exhibits an interesting linear flow-structure pitching southwest off the intrusive body. The following series of basic granites, etc. is characterized by a platy foliation. This gneissic texture strikes E SE—W, NW, and dips, next to the anorthosite, to the southwest and south. Farther southward the dip-angle becomes steeper and is vertical along an approximate line from Goodenow river to Polaris mountain. Still farther south the foliation is found slanting increasingly to the north. The intrusive rocks bordering the anorthosite, therefore, appear as a large wedge-shaped series, the southern margin of which lies almost horizontal and is intricately involved and interbedded with the older sediments which apparently underlie the whole magmatic complex. This result seems to corroborate to some extent previous conclusions of Doctors Daly and Bowen, reached from a merely theoretical standpoint.

PALEONTOLOGY AND PALEOBOTANY

Report by Rudolf Ruedemann, *Assistant State Paleontologist*

Three bulletins on the geology and paleontology of the State were completed during the year and published in May and June. They are:

Bulletin 258 The Utica and Lorraine Formations of New York. Stratigraphy—175p. 9 figs.

Bulletin 263 Idem. Systematic Paleontology. Part 1. 171p. 75 figs., 13 pls.

Bulletin 265 Some Silurian (Ontarian) Faunas of New York. 134p., 41 figs., 24 pls.

Part II of the fauna of the Utica and Lorraine formations of New York has also been completed during the year, both as to text and drawings, and is ready for the printer. It is the last part of the monograph of the Utica and Lorraine formations of New York and comprises the mollusca, crustacea and merostomata; among the crustaceans, a form that may represent the earliest of the barnacles, and among the merostomes, six new eurypterids from the Utica shale, where before only one form was known. Eurypterids of Ordovician age have hitherto been described only from the rocks of the State of New York, in Memoir 14 of the State Museum. These additional species are therefore of exceptional scientific interest.

The entire fauna of the Utica and Lorraine formations listed and described in the two bulletins comprises 312 species and varieties. Of these, ninety-five are new to science and another third had not before been recorded from the State, tripling the previously known fauna of the Utica and Lorraine formations. Striking differences in the facies of the Utica and Lorraine faunas that are brought out by the list to be published in the last installment of the monograph are described in a separate paper in this report. They indicate wide differences in the physical conditions surrounding the deposition of the Utica and Lorraine sediments.

Smaller papers have been published elsewhere; one on Fundamental Lines of North American Geologic Structure in the Twentieth Report of the Director, and others in the Pan-American Geologist and Science.

The field work consisted in mapping on the four quadrangles of the capital district and smaller collecting trips.

The Paleobotanist has given most of her time to Museum work. She supervised the completion of the Gilboa forest group, which

involving various new features of Museum work, such as restoration of whole trees with extremely delicate foliage, combination of actual geologic rock structures with an imaginary scene of an extinct forest, brought up many problems, both scientific and structural, that required much study. A description of the group, with a photograph, is given in a paper on New Museum Exhibits which follows in the report.

Miss Goldring is also engaged on the study of new crinoid and plant material that has come in during the year. Two papers dealing with this material are included in this report, and also a paper describing the recent Museum exhibits on which she has been engaged.

INDUSTRIAL GEOLOGY

REPORT BY C. A. HARTNAGEL, *Assistant State Geologist*

The value of the mineral production of New York State for 1924 amounted to more than $96,000,000. This is the largest annual value ever reported and represents nearly a threefold increase during the past 20 years. In order to present in a concise manner the mine and quarry products, together with quantities and values, the following table has been prepared:

Mineral Production of New York in 1924

PRODUCT	UNIT OF MEASUREMENT	QUANTITY	VALUE
Portland cement	Barrels	7 435 875	$13 460 594
Natural cement	Barrels	....	*a*..........
Building brick	Thousands	1 052 761	14 118 452
Pottery	....	....	8 421 523
Other clay products	....	....	3 678 564
Carbon dioxide	Pounds	....	*a*..........
Crude clay	Short tons	5 948	31 238
Diatomaceous earth	Short tons	199	12 995
Emery	Short tons	1 610	11 426
Feldspar and quartz	Short tons	17 686	120 739
Garnet	Short tons	7 428	623 472
Gypsum	Short tons	1 474 491	14 329 246
Iron ore	Long tons	303 386	1 448 616
Marl	Short tons	....	*a*..........
Millstones	....	....	18 215
Metallic paint	Short tons	14 522	63 955
Mineral waters *b*	Gallons	6 789 182	811 465
Natural gas	1000 cubic feet	6 196 000	3 632 000
Natural-gas gasoline	Gallons	476 753	49 639
Peat	Short tons	508	7 438
Petroleum	Barrels	1 440 000	5 245 000
Pyrite	Long tons	7 593	16 705
Salt	Barrels	14 091 486	6 739 597
Molding sand	Short tons	607 089	1 040 735
Other sand and gravel	Short tons	12 790 451	7 542 458
Sand-lime brick	Thousands	16 529	220 851
Slate	....	....	962 276
Granite	Short tons	68 360	211 766
Limestone *c*	Short tons	6 969 060	9 461 774
Marble	Short tons	64 220	532 358
Sandstone	Short tons	303 000	1 529 590
Trap *d*	Short tons	....	238 125
Talc	Short tons	78 340	1 162 488
Zinc ore	Short tons	40 350	606 320
Other materials	....	....	45 872
Total value	....	....	$96 395 492

a Included under other materials.
b Quantity and value partly estimated.
c Includes value of lime, but not value of limestone for cement making. Tonnage does not include amount used in lime making.
d Includes value of miscellaneous stone.

Molding Sands

During the year there has been issued a report on the molding sands of the Hudson river district written by Professor C. M. Nevin of Cornell University. This report is of much value to the molding sand industry since it contains not only information relating to origin and location and method of deposition of many beds of molding sands, but also laboratory tests adding much to our knowledge of the character and uses to which molding sand may be put. Standardization of grades of sand is one of the ends toward which the molding sand investigations are being aimed.

The production of molding sand in New York State at present amounts to over 600,000 tons annually. Most of this product is from the Hudson river district. The rapid depletion of the present developed molding sand beds of the Hudson river district has made it desirable to continue field operations with a view to the future expansion of molding sand areas and the possible discoveries of areas containing sands of a coarser type than those found in the Hudson river district, for which there is a ready market.

With this end in view Professor Nevin spent the month of July 1925 in the field, making a reconnaissance of prospective new territory. During this month thirty-five samples of sand were collected for examination and testing and more than 2000 miles were covered in making the investigations.

From Saratoga Springs north to Glens Falls, Professor Nevin reports a number of undeveloped areas of molding sand of commercial size. This territory lies north of the present development in the Hudson river district, and future operations for production of sands of the Albany type will be extended to this region.

Examination of the territory directly north of Glens Falls along Lake George and Lake Champlain did not indicate the presence of new areas of molding sand of commercial importance. Although surface materials were abundant they were in general too sandy and open.

In southwestern New York along the Allegheny river are extensive deposits, from which some shipments are already being made. As a result of the field work other untouched areas have been located, some of these located on Indian Reservation but unfortunately not available for exploration. There are also a number of other areas in western New York containing molding sand, which may reasonably be expected to be developed within the next few years.

The core sands in the region west of Rome were also included in the field studies. The district has already produced a considerable

amount of core sand, but Professor Nevin reports in addition large undeveloped deposits, some of which have a thickness of 50 feet. The sand, though of a rather fine grain for certain types of core work, contains but one-half of one per cent of lime—a feature which makes it highly desirable.

The sand dunes at the east end of Lake Ontario at Selkirk were also investigated, the sand of these dunes resembling the famous Michigan City core sand of very similar origin. Beach sands of a coarser type are adjacent to the sand dunes, making possible the production of at least two grades of sand. It is estimated that the sand dunes alone contain about 5,000,000 tons of molding sand, with shipping facilities possible by lake barges.

Natural Gas

The field work on the natural gas district of western New York, started in 1924, has been continued, Professor Henry Leighton of the University of Pittsburgh spending a month in the field during the past summer. The results of office and field studies are to be incorporated in a bulletin.

Professor Leighton's work was concerned in part with securing data in order to make possible a map showing underground relations of the gas-bearing strata. In Chautauqua county the position of the Medina sandstone as referred to sea level was plotted and results relating to structure have been plotted on maps. New developments in recent years have made available a number of well logs, which will be of much help in interpreting underground relations and depths of the gas-bearing rocks.

Among the new gas fields developed within the past year or two is one along Hunters creek about 4 miles northeast of Holland, Erie county. In September 1925 there were twelve producing wells and four drilling. A pipe line will conduct the gas to East Aurora. Some further studies were also made in the Pavilion field. Attempts to extend the field by drilling have not met with any degree of success.

In the Dansville region the gas field has been extended somewhat and a deep test that will probably go to the Trenton limestone is under way. The gas fields of Allegany county were also given some attention, and a number of well logs were obtained and the positions of the wells plotted on the map.

In Oswego county near the city of Fulton a good producing gas well has been brought in during the year. Other wells are being drilled in the county in hopes of finding additional producers.

Petroleum

Field studies on the petroleum areas of New York State, which were undertaken a few years ago, were completed during the summer of 1925, a month's field work having been carried on by Professor R. E. Somers of the University of Pittsburgh.

The oil fields of New York have now been producing for a period of 45 years. They comprise an area of 50,000 acres located in the counties of Cattaraugus, Allegany, and Steuben. Altogether there are some 15,000 producing oil wells in these counties. Although there has been no noteworthy expansion of the oil-producing areas during the past 25 years and no new sands of importance have been discovered, the productiveness of the field has nearly doubled since 1912, in which year but 782,661 barrels of petroleum were produced. The 1924 production amounted to 1,440,000 barrels which represents the largest output in a period of more than 30 years. The large increase in production is for the most part due to methods of flooding which have been introduced in the New York and Pennsylvania fields in recent years and which have attracted widespread interest throughout the country. With these flooding methods of increasing the production of oil, the field and laboratory investigations have been chiefly concerned.

Professor Somers' work included: (1) The collection of late production data. The figures of recent years are of extreme value in showing the increase in oil output due to the flooding method of exploitation. (2) Collection of late geological information, special attention being given to correlation and naming of the oil sands. (3) Collection of samples of water from various stages in the process of flooding. The water samples are to be analyzed in order to determine what changes if any take place in the composition of the water as it passes through the sand. (4) Samples of sand at five-foot intervals were collected from several wells. A study of these samples are to be made to show nature and variation of the sand.

ENTOMOLOGY

REPORT BY EPHRAIM P. FELT, *State Entomologist*

The unusually cool summer of 1925 was probably responsible in considerable measure for the abnormal behavior of insect life. There were comparatively few serious outbreaks and these were mostly by species which ordinarily escape notice.

Cottony maple scale, Pulvinaria amygdali Ckll. This all but unknown species in New York State caused a great deal

of apprehension and was responsible for a considerable loss in the peach orchards from Lockport eastward to Owego. This scale insect is very closely related to the cottony maple scale, Pulvinaria vitis Linn., a species which occasionally becomes extremely abundant in the southern part of the State, especially on soft maple. Both of these insects secrete a large amount of honeydew and this falling upon the foliage or the fruit of the infested trees affords a suitable medium for the development of a sooty fungus, the latter blackening the smeared surfaces and in the case of the peach materially reducing the value of the crop. In a few instances most of the fruit from individual orchards was sold to canneries instead of being disposed of in the open market. The Entomologist visited the infested area twice, making a preliminary examination on the first trip and later going over the territory more carefully with associates and attending a conference for the purpose of determining the best procedure in infested orchards during the late fall and the following spring. It was decided to advise spraying with a lime sulphur wash at winter strength in the fall or spring as a safe and possibly satisfactory method of preventing serious injury another season, this to be supplemented by spraying at the time the young were crawling with a lime sulphur wash, 1 to 40, to which 10 pounds of air-slaked lime were to be added for each 100 gallons, this latter having given the most satisfactory results in checking the development of young scales and the secretion of honeydew the past season. This outbreak as indicated above is unprecedented for New York State and the occurrence of parasites in some of the orchards and other considerations justifies a hope that there may not be severe injury another season.

European corn borer, Pyrausta nubilalis Hubn. The western area infested by this somewhat well-known insect has been considerably increased during the past year and the borer has become more abundant in certain sections, especially in the Silver Creek area. There is somewhat greater damage in this section than in 1924, although the injury is not serious and generally speaking there has not been a material increase in the numbers of the insect in New York State.

Very disquieting reports came in connection with the work of this pest in southwestern Ontario in particular, and owing to the potential importance of the borer, the Entomologist attended the European Corn Borer Tour and Conference in Ohio, Michigan and Ontario, Canada, September 29th to October 1st, for the purpose of making personal comparisons between conditions in the

Canadian area in particular and the infested sections of New York State. There has been a much greater increase in the infestation in Ohio corn fields east of Toledo than has been recorded for New York State. The most serious conditions were observed in the eastern part of Essex and the western part of Kent counties, Ontario, Canada. There is an area of about 400 square miles which is very badly infested, one section comprising some 10 square miles being most severely affected. We were informed that in this latter area, owing to the serious infestation of 1924, there had been during the past season a reduction in the acreage of about 75 per cent. It was stated that 100 per cent stalk infestation prevails throughout the 400 square miles and that in the case of corn planted about May 15th, there were thirty-five to forty-five borers to a stalk, while in the plantings from June 4th to 6th the average was approximately twelve borers to a stalk and in fields planted later, June 15th, some five or six borers to a stalk. It was noted that relatively fair fields of corn, making some allowance for conditions, were to be found throughout this section and occasionally at least rather near very seriously infested fields, this alone indicating that the time of planting or other local factors may have an important effect upon the degree of infestation. A number of the early planted fields in this area were practically total losses, most of the stalks being so badly riddled by the pests that they could be readily crushed between the thumb and the fingers and the few malformed ears being practically worthless. This extremely serious condition followed a year of unusual abundance of corn borer and a consequent 50 to 75 per cent reduction in the corn acreage, this latter serving to increase the infestation. Furthermore, it is stated that the middlewest practice of breaking off the ears and leaving the stalks in the field is largely followed in this area. These conditions lead us to hope that the agricultural methods in New York State are such as to make impossible the extreme damage of the past season in certain sections of Ontario. The European corn borer behaves so differently in various sections of the country and from season to season as to justify close observation of the entire situation for some years to come.

Destructive leaf feeders. The apple tent caterpillar, Malacosoma americana Fabr., was somewhat abundant in sections of Rensselaer and Columbia counties, and particularly in the eastern part and also in the southeastern portion of the State. The fall canker worm, Alsophila pometaria Harris, was also extremely abundant in southern Westchester county. Both insects

are somewhat perennial nuisances and are easily controlled by the judicious application of poisons or the adoption of other repressive measures.

Ten-lined inch worm, Erannis tiliaria Harris. The outbreak of the past season was forecast by the appearance in October 1924 of millions of light brown moths at the lights of many cities and villages in the State. The insects attracted general attention then and were the basis for the prediction of extended injury the following spring. The forecast was amply justified by the stripping of basswood, oak and maple over wide areas in the Adirondacks, the Catskills and the eastern section of the state, particularly, by the bright yellow, black-lined measuring worms an inch or more in length. The somewhat close restriction of these pests to the soft maples of swamps or the oaks and other trees on elevations was quite marked, the latter especially so in the eastern part of Rensselaer county. The report of wingless females being found in numbers in late fall suggests a continuation in restricted areas of the defoliation of the past season, though very probably stripping will be less general since there was no such flight of moths in 1925 as was observed the preceding year.

Elm leaf beetle, Galerucella luteola Mull. This insect continues to be somewhat of a pest on shade trees, serious injury, however, being much more restricted than in earlier years and very frequently limited to a few trees near some especially good winter shelter, such as a belfry, an open shed or an old building, shelters presumably offering many attractive crannies for the overwintering beetles.

Apple and thorn skeletonizer, Hemerophila pariana Clerck. This recent introduction appears to have passed its maximum and is probably being controlled to a very considerable extent by natural enemies or responding to unfavorable climatic conditions. It is possible that the cool summer was unfavorable for the development of the insect. It certainly is true that there has been no such extensive feeding and defoliation as was characteristic of 1923 and 1924. Even unsprayed trees escaped for the most part with very little damage.

Gipsy Moth, Porthetria dispar Linn. The Entomologist has continued to cooperate with the gipsy moth office of the New York State Conservation Commission, assisting and advising in relation to the temporary weather stations, the latter having been located during the past season at Hampton, Salem, North Petersburg, Austerlitz and Pine Plains, and also East Charlemont, Mass.

The balloon schedules of earlier years were followed closely and these stations were visited several times. The general results indicated by returned tags agree closely with those of 1923 and 1924, there being a very general easterly drift and relatively little in a westerly direction.

The Entomologist has also examined a number of the recent infestations in the barrier zone and in addition one just north of the New York State line, namely at Lacolle, province of Quebec. The infestations are cleaned up very thoroughly and promptly after discovery and all except the larger have been practically exterminated. These conditions justify the maintenance of the barrier zone, since it is proving an effective method of preventing further westward spread.

Birch leaf skeletonizer, Bucculatrix canadensisella Chamb. This small insect is sometimes extremely abundant and in 1924 showed a marked difference in the degree of infestation between the western slopes of the Berkshires and some areas on the eastern slopes where practically all the birch foliage was destroyed. A few records of injury by this insect were received during the past season but none of any moment.

Birch leaf miner, Fenusa pumila Klug. The Entomologist was fortunate in observing thousands of the adults of this recently introduced leaf miner upon gray birches at Stephentown on May 27th. The following day they were seen in much smaller numbers at Karner and by June 10th they had mostly disappeared from an area which compared closely in seasonal development with the Stephentown section. Field observations were continued at irregular intervals throughout the season and data obtained which indicate but two generations in 1925, although the time limits appear to be ample and observations in 1924 indicated some breeding until well into the fall. This insect appears to be extending its range. Its work was observed rather commonly a little south of Newburgh and also in the Woodstock-Tannersville area of the Catskills. A number of birches near the main line of the New York Central Railroad near Fox Ridge and Port Byron showed from the train in early September what appeared to be the characteristic work of this insect.

An unusual outbreak by forest leaf feeders, the red-humped oak caterpillar, Symmerista albifrons Abb. & Sm., and the maple trumpet skeletonizer, Epinotia aceriella Clem., on the sugar maples of Cortland county was brought to our attention through Dr G. G. Atwood, chief of the bureau of plant industry,

Department of Farms and Markets. The great abundance of the latter insect was particularly noteworthy. The feeding by both occurred so late in the season that no material damage resulted.

There was an unusual abundance of small leaf-mining caterpillars working in spruce and hemlock needles. They enter at the base and fasten the affected needles together with frass-filled masses of webbing. The Colorado blue spruce suffered in several localities through the work of one of these insects, Olethreutes abietana Fern. More than 200 moths were reared from one small flat spray with major dimensions of 9 by 12 inches. A related species, Epinotia nanana Treit., attacked the needles of the Norway spruce in a similar manner and a third species, Recurvaria piceaella Kearf., was also reared from affected spruce. All three of these species are practically unknown as pests in the eastern United States. A fourth species should be mentioned in this connection, namely Argyresthia freyella Walsm., the silvery gray cocoons of which were numerous upon the leaflets of red cedar, Juniperus virginiana. The caterpillar or larva of this last is also a leaf miner.

Lunate onion fly, Eumerus strigatus Fall. Because of the considerable interest of the federal authorities in ascertaining the status of this insect in the United States in relation to the possibilities of preventing further introductions through the importation of bulbs, the Entomologist made a systematic examination of iris beds in various parts of the State and succeeded in collecting adults at Saratoga, Amsterdam, Schenectady, Albany, Greenville and Athens in the eastern part of the State and at Geneva in the central portion, indicating a wide distribution and probably the establishment of the species in most, if not all these localities. Such collecting as was possible at Rochester, East Aurora and Fredonia in the western section of the State failed to establish the presence of the insect, though this by no means indicates the absence of the species. The special attention given to this insect resulted in increased interest in other pests of the iris and consequently a number of other species affecting this popular flower were submitted for identification during the summer.

White pine weevil, Pissodes strobi Peck. This common pest of the white pine kills the leaders of thousands of small trees annually and in certain sections is very abundant and injurious to recently set trees. The city of Troy has a large number of young pines on the slopes surrounding the Tomhannock reservoir northeast of the city and at the request of the division of forests and

lands, State Conservation Commission, the Entomologist made several examinations of the infested area and advised the city authorities as to the best methods of handling the somewhat serious situation. A very large proportion of the infested shoots were cut and burned before the weevils escaped, a procedure which is bound to reduce the infestation greatly.

Spiny witch-hazel gall, Hamamelistes spinosus Shimer. This has an interesting alternation of food plants since it produces a spiny, budlike gall upon the witch-hazel, the aphids issuing from these galls migrating to the leaves of various birches and occasionally becoming so extremely abundant as seriously to curl or deform much of the foliage. There were several outbreaks of this insect on ornamental birches reported from the southern section of the State and observations in the eastern portion of Rensselaer county showed this plant louse to be extremely numerous upon native birches. Furthermore, the infested trees were frequented in considerable numbers by Syrphid or flower flies and other enemies of plant lice, indicating that natural checks would soon reduce the infestation greatly.

Birch psyllid, Psyllia striata Patch. The above record in relation to birch aphids should be supplemented by data relative to this comparatively unknown jumping plant louse, a species easily recognized by the long woolly strands adhering to the body and drifting with the wind as series of curved, spreading, wool-like fibers. This insect was extremely abundant on birches at Karner.

American holly leaf miner, Phytomyza ilicis Curtis. Observations the past season showed a general and somewhat severe infestation by this insect at Westbury, Long Island. A very considerable proportion of the holly leaves had the entire upper surface mined and discolored, this being particularly evident on the sunny portions of the shrubs. The lower and more sheltered leaves showed only a few of the characteristic serpentine mines. This locality is near the northern limit for the species.

Elm lace-bug, Corythucha ulmi Osborn & Drake. A rather severe infestation by this insect, heretofore unknown in New York State and recorded from only one New England locality, was observed on a small group of elms at Brainard, town of Nassau, the foliage being so badly affected that it was well browned toward the end of the summer. Investigations later showed the tiny lace-bugs to be wintering in large numbers among the leaves and débris at the base of the trees. Consequently judicious burning would be a rather easy method of greatly reducing such an infestation.

Croton bugs, Ectobia germanica Linn. These insects, sometimes spoken of as cockroaches, are well-known pests of city dwellings. One of the Hudson valley cities experienced considerable difficulty with these insects after they had become established in a dump and multiplied to such a great extent as to be veritable nuisances in the neighborhood. It is easy to outline effective control measures. The difficulty is to suggest methods which will not involve too great expenditures.

Insects and Health

The relation of insects to health is a subject brought to the attention of the Entomologist in many ways and is a relationship which is becoming more apparent as knowledge along this line increases. Recognizing the importance of popular information on this phase of economic work, the Entomologist has prepared a bulletin discussing briefly the essential relations between insects and the dissemination of disease, a phase of entomology of as much importance to the dwellers of the cities and villages as to residents of the country.

Winds and the Dissemination of Insects

The studies of recent years along this line have been continued and there is now in hand to be published elsewhere an extended discussion of the part winds play in the dissemination of insects. The Entomologist has assembled data from all sections of the world and has attempted to interpret this in the light of information recently acquired through aviation and other studies of air currents. He has found numerous records indicating widespread aerial movements, presumably drifting rather than purposive flight, evidenced in part at least by the data in relation to southern and southwestern insects being found upon high mountains and more recently by the collecting of an aphid, Dilachnus piceae Panz., and a flower fly, Syrphus ribesii Linn., on the snowy surface of North-East Land, Spitzbergen Islands, north latitude 80°, under conditions which indicate that "hundreds of thousands and even millions" of these insects had been blown in a broad belt over the island, probably originating on the Kola Peninsula, a distance of over 800 miles in a straight line.

The data assembled raise a serious question as to there being a real or purposive migration among insects comparable to that known to be true of birds and may lead to a very considerable modification in our methods of recording distribution in the future.

As an outcome of earlier work with balloons mentioned above,

the Entomologist has outlined methods for the use of these in connection with investigation of air currents conducted by the Bureau of Plant Industry, United States Department of Agriculture, balloons being released the past summer from a series of stations from Texas north to the Great Lakes. Work was also started by the Bureau of Entomology, United States Department of Agriculture, at a station located at Tallulah, La., a number of balloons being liberated in the early fall at the time cotton moths were taking flight, in an effort to duplicate the presumed northward drift of these insects. Enough data were secured to show a general northward drift, though to date there is no record of one of these balloons covering the same distance as the cotton moth, something not surprising when the extremely small number of balloons, relatively speaking, is compared with the millions of moths which must participate in these movements.

Nomenclature

The Entomologist, owing to the very large number of genera and species of insects, is compelled to use a great many scientific names and is consequently more interested in the rules in relation to these than is the zoologist working in other animal groups. An examination of the some 140,000 generic names of animals shows that a very considerable proportion have been formulated more for the purpose of avoiding duplication throughout the entire series rather than of developing a systematic and suggestive diversity. The result has been a large number of names characteristic to a very slight degree of the groups they represent, in many instances differing from each other very slightly and in some cases being extremely long. Furthermore, because of present rules prohibiting duplications throughout this entire series, it is extremely difficult to find reasonably characteristic short terms for new genera now being proposed at the rate of about 1500 annually. These considerations led the Entomologist, in cooperation with Dr S. C. Bishop, State Zoologist, to propose a system of four letter prefixes, these latter using so far as possible characteristic initial letters of the major groups, the third and fourth letters, assigned alphabetically in a well-recognized sequence for differentiation between the families. In order to avoid a marked break with the present system, it is recommended that the prefix be written as a part of the generic name as we now know it, the latter also capitalized. It is believed that serious defects exist in a system which permits such unwieldy names as Brachygnathosuchus, Pseudaugochloropsis and

Pseudoheptaphlebomyia, such similar terms as Agroeca, Agroecia and Agroecus, and such meaningless designations as numerous anagrams, all serious and unnecessary defects in a branch of science standing for accuracy and presumably welcoming the cooperation of students. Names are simply designations and it is held that they should be so formed as to aid to the greatest possible extent in their ready placing and identification and that with the fewest possible objectionable features.

Collections

The transfer to the State Entomologist of the custody of the Erastus Corning magnificent collection of butterflies, title to remain with the Albany Historical and Art Society, was one of the last acts of our late Director, Dr John M. Clarke. This action resulted in bringing a notable collection under expert care and the housing of it with those of earlier local collectors, namely, the W. W. Hill collection of Lepidoptera, comprising some 10,000 specimens and representing over 3000 species, and the J. A. Lintner collection. These three, with the constantly increasing state collections, represent an assemblage of material of great value to all future entomological workers.

During the year there has been an exchange of certain species of mosquitoes or Culicidae with Eric Hearle of the Entomological Laboratory, Vernon, B. C., and as a result the Museum has acquired a number of very desirable additions. The New York State collection of Culicidae, carefully studied and revised by Dr William Matheson of Cornell University, was returned during the year with a number of valuable additions. The extensive series of parasitic flies belonging to the Tachinidae has been carefully studied by Luther S. West, a graduate student at Cornell University, and is to be returned in the near future.

The arrangement and determination of the insects in the collection has continued whenever opportunity offered and some progress along this line may be reported. The Anthomyid flies, best known because among them may be found such important pests as the cabbage root maggot, Phorbia brassicae Bouche, and the onion fly, Phorbia ceparum Meig., have been rearranged by Mr Young. He has also given considerable time to the dance flies or Empidae which are now in fairly satisfactory condition. The Oscinidae or Chloropidae, better known as frit flies or grass stem flies, have been largely rearranged and some progress has been made in the classification of the Phoridae or hump-backed flies, minute, difficult species.

There have been a number of desirable additions to the collections through field work, contributions and exchange as in previous years. It was possible this season to collect in the field an excellent series of the birch leaf miner, Fenusa pumila Klug., and also of the elm leaf miner, Kaliofenusa ulmi Sund. A large series of the spruce leaf miner, Olethreutes abietana Fern., was reared from infested material.

The accessions during 1925 and many of those in 1924 hitherto not placed have been cared for and a number of identifications of beetles or Coleoptera and flies or Diptera have been made in the course of this work. It has also been necessary in connection with the increase in the size of the collection to repin and rearrange a number of boxes which had become badly overcrowded.

Attention was called last year to the need for another assistant in entomology and this has not decreased with the passage of time. Experience in other museums has shown that systematic or taxonomic work is very commonly in arrears, although well classified collections are necessary for the best work. There is in the New York State Collection of insects a large amount of unclassified material which can not possibly be arranged with the present staff, since numerous interruptions due to the necessities of identifying miscellaneous sendings from correspondents and other hindrances greatly delay systematic work upon the various groups. The Division is failing to meet its opportunities along a number of lines on account of insufficient assistance.

Publications

A folder entitled School Guide to Insects and Books About Insects, was issued early in the year and appears to have been of material service in many localities, if one may judge from the demand for copies. The Key to Gall Midges, A Résumé of Studies i-vii, Itonididae, dated February last, brings to a conclusion an extended monographic study of the gall midges of America, a small and comparatively neglected group comprising a large number of extremely interesting forms and including such important pests as the wheat midge, Contarinia mosellana Gehin, and the Hessian fly, Phytophaga destructor Say.

The Entomologist has prepared during the year a number of popular notices regarding various injurious insects. One of the most important entitled Insects and Human Welfare, was published in the Scientific Monthly for December.

Office Matters

The demands from schools, both teachers and pupils, for information regarding the insects of the State are increasing and have resulted in the exhaustion of practically all the available literature especially suited to their needs. It is obvious that such calls indicate a somewhat general interest in insect life and seekers for this knowledge should be encouraged in every possible way.

Lectures

The Entomologist has lectured on insects and disease before the senior class of the Albany Medical College, in a postgraduate course in infections, diseases and public health conducted by the State Department of Health, and before the staff of the division of laboratories and research, State Department of Health. He has also given a number of other lectures or talks on insects before various organizations in different parts of the State.

General

The work of the office has been materially aided as in the past year by the identification of a number of insects through the courtesy of Dr L. O. Howard, chief of the bureau of entomology, United States Department of Agriculture, and his associates. There has been effective and close cooperation with the State Department of Farms and Markets, particularly the bureau of plant industry, the State Conservation Commission, especially the gipsy moth office, the State Department of Health, the State College of Agriculture at Cornell University, the State Experiment Station at Geneva, various county farm bureaus and other public welfare organizations. A number of correspondents have donated specimens and rendered valuable service by transmitting data respecting different insects and by assisting in other ways.

ZOOLOGY

REPORT BY SHERMAN C. BISHOP, *Zoologist*

The routine work of the Zoologist and his assistants may be briefly summarized under the following heads:

Care of Collections

The great majority of zoological specimens are essentially perishable in character and require constant attention. They collect dust and dirt and must be cleaned. Specimens in alcohol or other liquid

preservatives must be examined at frequent intervals to prevent loss by evaporation. Bird and mammal skins and mounted specimens on exhibit and in the study collections are subject to the attack of museum pests, beetles, moths and other insects and must be fumigated.

Replacement of Specimens

Specimens long exposed to light, dust and constant changes in temperature deteriorate and must be replaced from time to time. This is especially true of the skins of birds and mammals whose color and patterns fade. Colors of naked skins, horns, beaks and claws may be restored by painting but feathers and fur offer greater difficulties.

Collection, Preservation and Classification of Specimens

The collection of suitable materials requires active field work on the part of the Zoologist. The preservation of the materials thus brought together is partly accomplished in the field and partly in the Museum's workrooms and requires considerable technical skill on the part of the assistant to the Zoologist. It is greatly to the credit of the assistant that all materials intrusted to his care have received intelligent and prompt treatment.

The Zoologist is responsible for the proper identification of the zoological materials added to the Museum's collections by field work, purchase and exchange but he can not be expected to have an intimate knowledge of all the individuals composing the various groups. If he is to accomplish anything of value he must confine his efforts to a few subjects. The division is undermanned. Specialists in ichthyology and mammalogy should be added to the staff if the Museum is to study and report on these groups. There is a constant demand for information relative to the history, habits and economic importance of various fishes, mammals and other animals and the Museum should be in a position to answer these inquiries. Some of these questions can not be answered because they have reference to subjects which have never been investigated and can not be until some adequate provision is made at the Museum.

Field Work

Field work during the past year has been carried on in various parts of the State and in northwestern Pennsylvania. In July 2 weeks were spent in Essex county, part of the time in the vicinity of Keene Valley and the remainder at Adirondack Lodge. Ex-

tensive collections of arachnids, reptiles and amphibians were added to the Museum's series. In August a short excursion was made to Honeoye lake where a fine series of the timber rattlesnake, Crotalus horridus was secured. In early September western New York and northwestern Pennsylvania were visited for the purpose of studying the life history and breeding habits of the Hellbender, Cryptobranchus, the largest salamander in the western hemisphere. Shorter trips were made in the vicinity of Albany, continuing investigations on the local fauna which have been carried on during the past few years.

The State Museum was fortunate in having on its staff of experts during the past summer Dr Francis Harper, secretary of the Boston Society of Natural History. Doctor Harper collected and studied the smaller mammals in various parts of the State and has added a series of study skins and skulls to the Museum collection. A more detailed account of the summer's work is appended to this report.

Classification and Arrangement of Specimens

The Museum's extensive collection of myriapods has been studied and completely revised by Professor J. W. Bailey of Mississippi College. This collection is the most complete in existence for the area covered, New York State.

New Groups and Exhibits

Several new groups now in course of construction have been designed to show something of the life history and breeding habits of several common reptiles and amphibians. The work of reconstructing the animals and their eggs is in charge of F. H. Stoll of Brooklyn, N. Y., an accomplished technician in wax, glass and plaster. The materials on which the studies are based have been furnished in most part by the Division of Zoology.

Without the special equipment of a zoological garden it is impossible to exhibit many kinds of living animals, but it has been found possible to place in Zoology Hall a number of reptiles and amphibians whose interesting habits have attracted the attention of a large number of visitors. The specimens exhibited include several species of snakes, turtles, lizards and salamanders.

In response to the growing interest manifested by the public in native birds, the Division of Zoology has installed a temporary exhibit showing the common winter birds of the capital district grouped according to the habitat in which the various species may

be found. The exhibit has been prepared by H. H. Cleaves, ornithologist and lecturer on wild life subjects, whose services have been secured during the absence of the taxidermist, Arthur Paladin.

Correspondence

Specimens of all kinds are being received at the State Museum from teachers, pupils in the public schools, museum workers and others interested in natural history. Identifying and reporting on these specimens often involve considerable study and correspondence but is regarded as one of the proper functions of the division.

Investigations

The Zoologist has continued his investigations on the life histories and habits of the New York reptiles and amphibians and has nearly completed the section dealing with the salamanders. The large collections of spiders and other arachnids which have been brought together during the past 10 years are being studied and have furnished material for several reports, some of which have been published as bulletins of the State Museum.

Publications

During the past year the following papers have been published:

Studies in New York Spiders: Genera Ceratinella and Ceraticelus; with C. R. Crosby

The Life of the Red Salamander

Singing Spiders

Two New Spiders from the Blue Ridge Mountains of North Carolina; with C. R. Crosby

An Egret and Little Blue Heron in Rensselaer County, New York

In Press:

The Spiders of New York: A Distributional List; with C. R. Crosby

The Phalangida of New York: A Distributional List; with C. R. Crosby

Notes on the Spiders of the Southeastern States with Descriptions of New Species

A Genus and Two New Species of Spiders Collected by *Buto quercicus* Holbrook

Records of Some Amphibians and Reptiles from Kentucky

Zonitoides arboreus (Say) in Mammoth Cave, Kentucky

Science and Scientific Names; with E. P. Felt

Prepared:

Notes on the habits and Development of Necturus maculosus (Raf.)

Suggestions

If the proper exhibition of materials pertaining to zoology is regarded as an important function of the State Museum, an effort should be made to secure the services of a competent preparator. It is not to be expected that any one preparator will be qualified to cope with all of the many intricate problems which arise but he should be able to handle a considerable number of them.

NEW YORK MAMMALS

By Francis Harper

In view of the decided need of increasing our knowledge of the distribution, habits, life histories and economic status of New York mammals, and also of making additions to the study collection of mammal skins in the State Museum, the writer was authorized to engage in field work for these purposes during the past summer.

In early July a small collection was made in the Hudson Highlands, a region whose fauna has been made known principally by the late Dr Edgar A. Mearns. A mammal of particular interest in this part of the State is a form of the red-backed mouse (genus Evotomys). Since there has been some question as to the exact species or subspecies represented by the single specimen that Doctor Mearns was able to secure, a special effort was made to collect additional specimens. By concentrating on certain sphagnous areas that occur in the most elevated portions of the Highlands, I was able to obtain three samples of Evotomys, which will doubtless be sufficient for finally determining the identity of the local form.

The distribution of the Allegany cave rat (Neotoma pennsylvanica) in this State is apparently limited to the Hudson Highlands, where it has been recorded from only a few localities. During the present season a specimen was trapped on Schunemunk mountain, and several other new locality records were secured.

From the middle of July to the latter part of August, field work was carried on in the Adirondacks, principally in the following localities: Indian lake in Hamilton county, and Chapel pond and

Adirondack Lodge in Essex county. Opportunities were sought for studying mammalian life in environments that have been affected to the least possible extent by civilization. One result of such studies may be the gaining of a more definite idea of the composition and interrelations of the Adirondack fauna during past centuries, before the white man's vastly disturbing influence upon nature began to be felt there. In view of the important distributional relations between plants and animals, much attention was given to the vegetation of the various ecological areas or habitats, from the treeless summit of Mount MacIntyre to the marshes and watercourses of the valleys. The altitudinal distribution of the various mammals was another matter given particular attention, since there are large gaps to be filled in our knowledge thereof. Information concerning the weights of mammals, though desirable and useful, is very meager or even totally lacking, in the case of many species; therefore the weight of nearly every specimen taken during the season was noted to the fraction of a gram. Female specimens were dissected for information regarding the season, number and development of embryos. Some photographs of mammals were secured by flashlight and a considerable number of other photographs were taken to illustrate the vegetation and topography in various habitats.

About fifteen species of mammals, represented by seventy-four specimens, were collected in the Adirondacks, and information of value was obtained concerning others. Those collected include the following: masked shrew (Sorex personatus personatus), big-tailed shrew (Sorex dispar), eastern short-tailed shrew (Blarina brevicauda talpoides), New York weasel (Mustela noveboracensis noveboracensis), northeastern mink (Mustela vison vison), northeastern chipmunk (Tamias striatus lysteri), red squirrel (Sciurus hudsonicus), Canadian white-footed mouse (Peromyscus maniculatus gracilis), bog lemming (Synaptomys sp.) eastern red-backed mouse (Evotomys gapperi gapperi), eastern meadow mouse (Microtus pennsylvanicus pennsylvanicus), house rat (Rattus norvegicus), northern woodland jumping mouse (Napaeozapus insignis insignis), southern snowshoe rabbit (Lepus americanus virginianus), and probably one or two others whose status has not yet been fully determined. Sorex dispar and Synaptomys are among the rarest of New York mammals in collections.

Close to the summit of Mount MacIntyre, which has an elevation of 5112 feet, three species, Sorex personatus personatus, Peromyscus maniculatus gracilis, and Evotomys gapperi gapperi, were obtained, and signs of another, Lepus americanus virginianus, were abundant. On the lower but likewise treeless summit of Mount Wright, which rises to 4585 feet, a Microtus sp. was collected.

Among the most interesting spots investigated were the ice caverns and talus slopes near Chapel pond and at Indian Pass. These localities yielded Sorex personatus personatus, Sorex dispar, and perhaps still another member of the same genus, in addition to several more ordinary species.

BOTANY

Report by Homer D. House, *State Botanist*

Scientific Investigations

The investigative work of the State Botanist during 1925 has been directed chiefly to a study of the flora of certain local areas, particularly in the vicinity of Newcomb, Essex county. Collections and field studies have also been made in other sections of the State. A detailed account of these investigations will be presented elsewhere. A large number of fungi, both parasitic and saprophytic, collected chiefly during 1925 are being studied in collaboration with Dr John Dearness and will be reported upon later. The mycological studies on the collections of 1924 have been completed and will be presented in the State Botanist's formal report.

Contributions to the State Herbarium

The following list indicates the chief sources of additions to the state herbarium by contribution and exchange during the past year:

Martha C. Carter (estate), Oneida	400
Elam Bartholomew, Stockton, Kans. (exchange)	200
Gray Herbarium, Cambridge, Mass. (exchange)	101
W. C. Ferguson, Hempstead	100
C. A. Brown, Albany	85
Mrs. O. P. Phelps, Gansevoort	10
Mrs Franc F. Pugsley, Pittsford	7

Other specimens have also been contributed by a number of correspondents. The most noteworthy contribution, not mentioned above is the Dr J. V. Haberer collection. This collection numbers upward of 10,000 specimens and constitutes a most valuable addition to the herbarium of the State Museum. Only a portion of the

collection has been received prior to January 1, 1926 and a more detailed account of the material will be deferred until a later report. It is eminently proper, however at this time to offer a brief sketch of his life and botanical activities.

The Dr J. V. Haberer Collection. Along with the Charles S. Sheldon collection, received in 1915, this ranks as the most notable gift to the herbarium of the State Museum. Dr Joseph Valentine Haberer was born at Utica in 1855, and died at Utica on December 7, 1925, only a few days after he had conveyed his herbarium to the Museum. His education was received in the public schools of Utica and the College of Physicians and Surgeons of Columbia University. In his chosen profession he ranked high and enjoyed a successful practice in Utica and its vicinity throughout his life.

In botanical circles he was widely known as one of the best of amateur botanists and a discriminating collector. His interest in plant life was enthusiastic, continuous and perhaps often to the neglect of his professional duties. In 1866 he was instrumental in the organization of the Asa Gray Botanical Club of Utica and was long its president. Asa Gray was born near Utica and spent part of his early life there so that the name of the organization was particularly appropriate. The society flourished for many years but local interest in botany declined and the society no longer has an active membership. Doctor Haberer's collections were made almost exclusively in central New York. He explored carefully all of the region of southern Herkimer county, most of Oneida county and made repeated excursions into the southern Adirondack region of Hamilton and northern Herkimer counties. His cottage on the shore of Oneida lake near South Bay where he spent most of his summer months was his base for botanical exploration of the entire Oneida lake region. He usually collected in quantity and as a consequence has contributed many valuable specimens to the herbaria of Harvard University, the National Herbarium at Washington, the New York Botanical Garden and the New York State Museum. Students of the difficult plant groups such as Viola, Crataegus, Carex, Botrychium, etc., have made abundant record of his critical field observations and extensive collections. Several species and varieties of plants have been named in his honor, the best known being a variety of the Ternate Botrychium (Botrychium obliquum var. Habereri) named by the late Benjamin D. Gilbert, a well-known authority on ferns. Doctor Haberer is survived by three sons, all of Utica. His wife died in 1913 and his only daughter, Mary Isabella, in 1910.

The Martha C. Carter Collection. The herbarium of Miss Martha Celette Carter, donated to the Museum in 1925 by her sister, contains about 400 specimens, nearly all of which were collected in the vicinity of her home, Oneida, and around Oneida lake. Miss Carter was born at Oneida on July 25, 1869 and died there on September 6, 1924. After attending the Oneida schools Miss Carter studied botany under the late Dr L. M. Underwood at Syracuse University, from which institution she was graduated with honor in 1892. Later she studied china painting and in this art as well as in water colors and oil achieved a statewide reputation. An ardent lover of flowers and outdoor life, she derived from her association with Doctor Underwood the necessary scientific attitude which resulted in the formation of a most noteworthy herbarium of the local flora, a collection which forms a valuable addition to the collections of the State Museum.

Additions to the State Herbarium. The total number of specimens added to the collections from all sources during the year 1925 is 2183, classified as follows:

Collections by the State Botanist	
Ferns and flowering plants	595
Fungi, mosses and lichens	685
Exchanges and contributions	903

The collections by the State Botanist and his temporary assistant were made in the counties of Albany, Columbia, Essex, Fulton, Hamilton, Herkimer, Madison, Oneida, Oswego, Otsego, Saratoga, and Warren.

Identifications

The State Botanist has been called upon during the year to identify 520 specimens of plants, including many edible and poisonous mushrooms, and plant disease fungi. These identifications were requested by 142 persons, mostly by letter, some of them, however, by personal visits to the office.

Lectures

During 1925 the State Botanist has delivered seven lectures before various organizations upon the subjects of plant life and wild flowers.

ARCHEOLOGY

After more than 18 years of service, Arthur C. Parker, former Archeologist, severed his connection with the State Museum on January 1, 1925, to assume the duties of director of the Municipal Museum at Rochester, N. Y. Since March 1, 1925, the work has been carried on by the present Archeologist.

A great deal of time has been spent in putting in order older collections and miscellaneous specimens. The archeological series of negatives has been brought together and systematically arranged in the office files, and the same attention has been given to photographs, maps and drawings. The entire subject catalog has been revised and listed under new and simple headings to avoid duplication. The ethnological storage room has been thoroughly renovated and provision has been made for temporary storage room for collections not yet cataloged.

Field Inspections

Field inspections have been made at various sites during the year. Among these are the farm of Mary H. Stanley near Chittenango Falls, where indications of only temporary camp quarters were found; the Charles Dockstatter farm and the adjoining Floyd Gates farm near Jamesville, which examination showed to be once the site of Iroquois occupation of the early historic period; sites in the vicinity of Cazenovia, Pompey and Manlius have also been examined.

During road grading operations on the Dutchtown road, seven Indian graves were unearthed on Sand Hill, a historic Mohawk site 1¼ miles northwest of Fort Plain and about a half mile due north of the site of Old Fort Plain. The Archeologist was not notified in time to prevent tampering with the graves, with consequent scattering and destruction of materials. Perfect Iroquois clay pottery vessels were reported smashed, and amateur collectors obtained traders' brass kettles, a few beads and a human effigy carved in bone. The burial site was directly in front of the Klock farmhouse, on the east side of the road. The front lawn, over a distance of 100 feet, was honeycombed with trenches; but the only article of interest found, except a few fragmentary human bones at a depth of 3½ to 4 feet, was the base of an early graphite crucible encrusted on the bottom and sides with a heavy layer of fused brass. This

was found at a depth of 40 inches in front of the north end of the farmhouse.

The Otstungo prehistoric site (number 38, Montgomery County, of Parker's Archeologic History of New York) was visited by the archeologist and Douglas Ayres jr of Fort Plain, and two days were spent in an attempt to locate the hitherto undetermined burial spot in connection with this ancient village. Results were negative or only slightly favorable and further investigations will be needed to locate the burial ground. Some of the public-spirited citizens of Fort Plain have urged that this prehistoric Mohawk village, which is one of the best examples of natural fortifications in the State, be preserved. This admirable undertaking has the indorsement of the archeologic division, with the hope that the site will in time be added to the group of state reservations now existing.

The New York State Archeological Association

This association came into existence in March 1916, when the Lewis H. Morgan chapter was organized at Rochester. This chapter today has a membership of 375, with Alvin H. Dewey president; Walter H. Casseber, secretary; Edwin G. Foster, treasurer. The association is successfully achieving the purposes for which it was formed, in recording the results of its work; preserving and protecting the ancient sites of aboriginal occupation within the State; encouraging the scientific collecting and cataloging of Indian artifacts and accomplishing much more in arousing and holding the interest of its members in the study of New York archeology and ethnology.

A Long Island chapter was organized at Southold in August of this year with eleven members, enthusiastic students of the archeology of the eastern end of Long Island, who had been working for years without coordination. Much work has been accomplished during the past few months at "Old Southold township" and a number of burials have been excavated, one of which revealed a very remarkable series of ceremonials, and another a very unusual group of aboriginal domestic utensils. The chapter has already been presented with a very desirable plot of ground by one of its members and it is hoped that a museum will be built there in the near future. The New York State Museum, through the division of archeology, is ready to cooperate in any possible way in the formation of new chapters.

Rev. Dr William M. Beauchamp

1830–1925

In the passing of William M. Beauchamp on December 13, 1925, the city of Syracuse has lost its "grand old man," for he was the oldest Episcopal clergyman in the central New York Diocese; Onondaga county lost its foremost historian; the State of New York has lost its dean of archeology, for Doctor Beauchamp was a venerable and highly respected authority on this science.

Doctor Beauchamp was born at Coldenham, N. Y., on March 25, 1830. As a young man he became interested in the study of archeology and ethnology and devoted most of his life to research in these sciences. The citizens of the State have been greatly enriched by the knowledge and data gathered by Doctor Beauchamp and preserved for them in the many bulletins which he wrote for the State Museum. He was honored with many distinctions, but none seems more fitting than the one bestowed on him by the Onondaga nation when he was adopted as a member of the Eel clan and called "The Beautiful, or Perfect, Rainbow."

FAUNAL FACIES DIFFERENCES OF THE UTICA AND LORRAINE SHALES

By Rudolf Ruedemann

In part I of the monograph of the Utica and Lorraine formations of New York (New York State Museum Bulletin 258, 1924) the writer fully discussed the origin of the black shales of the Cincinnatian (*ibid.* p. 73) and arrived at the conclusion that the black graptolite shales of New York State were deposited in the deeper water of basins; in the case of the Schaghticoke, Deep Kill and Normanskill, shales in narrow basins running in the direction of the Appalachian geosyncline; in that of the Utica shale in local depressions southwest and west of Adirondackia, of a more widely extending epicontinental sea. The fauna of the typical graptolite shales of the Lower Ordovician was described as containing only a few pelagic forms besides the graptolites, that of the Utica and associated shales (Canajoharie, Atwater and Deer River shales) as containing larger faunas, corresponding to the more calcareous composition of the shales. These faunas were also recognized as greatly depauperated when compared with those of the contemporaneous sandstones and gray shales of the upper Schenectady beds in the east, and the Cobourg limestone in the north in the case of the Utica shale; and of the Trenton limestones with their luxuriant life in the case of the contemporaneous Canajoharie shale.

The completion of a faunal table for the third and last instalment of the monograph of the Utica and Lorraine formations has brought to the writer's notice some striking differences in composition between the faunas of the black shales and the gray shales and associated sandstone of the Upper Ordovician which throw an important light on the character of the two facies represented by these shales. It is the purpose of this paper to point out these differences in the biota of the shales and their bearing on the problem of the graptolite shales.

The following list shows the number of species of each class found in the black shales and in the gray Lorraine shales and interbedded (more or less calcareous) sandstones.

CLASS	NUMBER OF SPECIES		PERCENTAGE OF FAUNA	
	Utica etc. black shale	Lorraine gray shale	Utica etc. black shale	Lorraine gray shale
Plants	*5*	1	*4.6*	.5
Sponges	*11*	...	*10*	....
Corals	...	1	....	....
Graptolites	*23*	8	*21*	3.8
Crinoids	...	4	....	....
Worms	9	4	8.3	2.0
Star fishes	1	...	....	....
Bryozoans	4	*32*	3.7	*15.3*
Brachiopods	12	*33*	11.1	*15.8*
Pelecypods	5	*63*	4.6	*30.1*
Gastropods	4	*30*	3.7	*14.4*
Cephalopods	*13*	6	*12*	2.4
Trilobites	7	11	7.4	5.3
Ostracods	4	13	3.7	6.2
Cirripedes	1	2	....	....
Phyllocarids	2	...	....	....
Merostomes	*6*	1	5.5	.5
Total	108	209		

The black shale at Six Mile creek near Rome, which furnished the famous material of Triarthrus eatoni and of Cryptolithus tesselatus retaining the appendages, has hitherto been considered as of Utica age, but has been proved by the writer in Bulletin 258 to belong with the Frankfort shale. The biologic aspect of the fauna of this shale is, however, typically that of the other black shales and its fauna is therefore here counted with the black Utica shale. It is doubtless a local continuation, in the center of the sinking basin, of Utica conditions into Frankfort (Lorraine) time.

The table brings out the following essential differences in the fauna of the black and gray shales respectively. The former is characterized by the preponderance of seaweeds (5, 4.6 per cent), sponges (11, 10 per cent), graptolites (23, 21 per cent), worms (9, 8.3 per cent), cephalopods (13, 12 per cent), and merostomes (6, 5.5 per cent) in absolute numbers and in relative percentage over the other biota of the assemblage and the corresponding numbers of the Lorraine beds. While these groups are not at all or only scantily represented in the gray Larranio shales, the latter contain large absolute numbers of species and relatively large percentages

of bryozoans (32, 15.3 per cent), brachiopods (33, 15.8 per cent), pelecypods (63, 30.1 per cent) and gastropods (30, 14.4 per cent).

A more detailed comparison of the fossil associations of the black Utica and gray Lorraine shales brings out the following facts:

The seaweeds of the Utica shale while rarely preserved distinctly enough to invite description, are nevertheless so omnipresent in macerated small patches that they undoubtedly constituted the principal source of the organic matter of the black shale (N. Y. State Mus. Bul. 258, p. 76, 84).

The sponges which were found in the Utica shale are all primitive Hexactinellida, like the sponges that have been found in the black Canadian shales at Little Metis, Quebec, and in Europe. They occur at certain horizons in great abundance, as in the upper Utica shale at Holland Patent.

The graptolites are everywhere present in the black shales and frequently in myriads to the exclusion of everything else, as Climacograptus typicalis at various horizons of the upper Utica. The few species observed in the Lorraine gray shales and associated sandstones are never of profuse occurrence and as a rule are scattered and rare finds.

Corals and crinoids are absent altogether in the black shales.

The worms with nine species constitute 8.3 per cent of the fauna. Undoubtedly there were many more forms which on account of their lack of hard parts escaped fossilization.

There were four species of bryozoans observed in the black shales as compared with thirty-two in the gray shales and alternating sandstones. Two of these are varieties of Spatiopora lineata Ulrich and occur only attached to cephalopod shells of the two others, one, Prasopora cf. contigua Ulrich, has been found only in one individual, and only the fourth, Hemiphragma bassleri, has been obtained in large zoaria but is also of very rare occurrence. The bryozoans are therefore by no means a regular constituent of the black shale fauna.

The brachiopods are not regular constituents of the black shale fauna either. It is true that there are twelve species recorded from the black shale as compared with thirty-three from the gray shale and sandstone, but these are nearly all minute forms with phosphatic-chitinous shells, namely, two forms of Leptobolus, two of Lingula, one of Trematis, one of Schizocrania, one of Schizambon and one Orbiculoidea. The remainder are a small Dalmanella found in the Utica shale near the top, a small Platystrophia, one example, a unique large example of Orthorhynchula linneyi

(James) and the small Camarotoechia (?) humilis of the Frankfort shale. This brachiopod biota contrasts strongly with that of the Lorraine gray shales and alternating sandstones with their multitudes of Dalmanellas, and other orthids; of Plectambonites and gigantic Rafinesquinas. The brachiopod fauna of the black shale has for the most part the appearance of having been attached to seaweeds or other floating objects and Schizambon minutus has been found only attached to patches of eurypterid skin.

The contrast between the pelecypod component of the two faunas is especially striking; there having been found but five species in the black shale against sixty-three in the gray shales and sandstones. The lamellibranchs of the Utica are of rare occurrence and very small forms, the only exception being Cuneamya subquadrangularis, which reached a length of about an inch but was found in only one example. Against this impoverished biota stand the multitudes of large Modiodesmas, Modiolopses, Pterineas, Byssonychias and Orthodesmas of the Lorraine beds.

The gastropods have likewise only an extremely depauperated representation in the black shales, the biota consisting of a minute Strophostylus, a small Holopea found in only one individual and two Conularias that are of doubtful reference to that class of mollusks. Against this stand thirty species in the Lorraine gray shales and sandstones with many large and abundant individuals and a great variety of genera.

The cephalopods, on the other hand, in contrast to all other mollusks, find their largest representation in the black shale, with thirteen species out of a fauna of 108 species against six species out of one of 209 species for the Lorraine beds. They constitute therefore 6 per cent of the Utica fauna and but 2.4 per cent of the Lorraine fauna. The Utica biota of cephalopods consists mostly of straight orthoceratites (Geisonoceras, Endoceras, Cycloceras), small Trocholites and the rare species Oncoceras pupaeforme. Small individuals of Geisonoceras are found sometimes in great abundance, but also larger individuals occur as the Geisonoceras amplicameratum of the upper Utica which was figured in the third instalment of the monograph and which attained a length of 2 feet. In one case the shattered conch of a large Endoceras was found in the Utica shale. In contrast to this larger biota of smaller cephalopods stands the smaller number of Lorraine forms which, however, consist of much larger species of Endoceras and Actinoceras.

The trilobites with seven species in the black shale against eleven in the Lorraine shales apparently are as well represented in the former as in the latter. It is to be considered, however, that one of these eight is Cryptolithus bellulus found in the black Frankfort shale at Six Mile creek; two others are species of Triarthrus; one is the Ogygites latimarginatus of the Collingwood; one Homotelus stegops, a Lorraine form, appearing in the top beds of the Utica; two others Proëtus beecheri and Odontopleura crosota, were found as very rare fossils in the black shale of Frankfort age at Six Mile creek near Rome. In the Utica shale itself only species of Triarthrus occur and it should be noted that with the exception of the Ogygites of the Collingwood shale and the Homotelus of the top of the Utica all species consist of small forms indicating unfavorable conditions. Against this stand the common Homotelus stegops of the Lorraine, a large Isotelus and two species of Calymmene and two of Odontopleura in the Lorraine shales. It should also be noted that a Triarthrus (T. huguensis Foerste) and Cryptolithus bellulus continue into the black shale intercalations of the lower Lorraine (Whetstone Gulf) beds and are extremely common there in places (N. Y. State Mus. Bul. 258, plate facing p. 112). The trilobite biota of the black shale is a very restricted one, though represented by an abundance of individuals in some horizons.

The ostracods are represented in the black shales only by a few primitive forms that are not very abundant in individuals.

Of supposed cirripedes the Utica shale has furnished the remarkable Eobalanus informans Rued. attached to the cephalopod shells and suggesting an early barnacle, while in the Lorraine shales the detached plates of Lepidocoleus are frequently observed.

The phyllocarids of the black shale consist of a swarm of the small Ceratiocaris timida Rued. found in the paragastric cavity of a sponge (see part III of the Utica and Lorraine Formations) and a group of telson spines found in the shale at Six Mile creek near Rome. No remains have as yet been observed in the gray Lorraine shales.

The merostomes have afforded six species represented by fairly complete individuals in the Utica shale, but only a single telson spine in the Lorraine shale. In one case (figured in part III, *op. cit.*) two individuals (Eurypterus rusti, Pterygotus walcotti) were found rolled into a round mass suggestive of the

alga Discophycus of the Utica shale. It is very probable that we have here before us cast skins that settled at the bottom and drifted about there. It is notable that also the black shales of the Normanskill beds and of the Schenectady beds in the Ordovician and the thin black shale laminations intercalated between the sandstones of the Silurian Shawangunk grit have afforded large assemblages of eurypterids (Mem. 14, N. Y. State Mus.).

It clearly follows from this analysis that the black shales of the Utica and Lorraine formations are characterized by a very distinct fauna that contrasts with that of the gray shales and alternating sandstones of the Lorraine as much as does the Cobourg limestone of equal age with the upper Utica. A comparison of the fauna of the black Canajoharie shale with that of the equivalent Trenton limestone would bring out still greater differences and the thinner intercalations of black shale in the Schenectady and Snake Hill beds show similar assemblages to those of the Utica and Canajoharie shales.

The fauna of the Canajoharie shale as described by the writer in The Lower Siluric Shales of the Mohawk Valley (N. Y. State Mus. Bul. 162, 1912, p. 15 ff., see especially p. 23) consists of graptolites, sponges, small brachiopods, mainly with phosphatic-chitinous shells (Leptobolus, Lingula, Schizocrania) besides small specimens of Dalmanella and Rafinesquina; small lamellibranchs referable to Pterinea, Prolobella, Ctenodonta and Whiteavesia; a few small gastropods (Clathrospira, Liospira), small Orthoceras-conchs, among trilobites mainly Triarthrus becki and small Calymmenes, cirripede plates (Lepidocoleus, Turrilepas) and ostracods of the genera Primitiella and Ulrichia.

The aspect of the black shale faunas in the Mohawk valley remained therefore entirely the same from the Canajoharie shale of Trenton age to Lorraine time. These faunas therefore constitute a very distinct facies pointing to a definite condition in their habitat. Let us see now what this may have been as derived from the nature of the faunules.

We have already in part 1 of the monograph of the Utica and Lorraine formations (N. Y. State Mus. Bul. 258, p. 77 ff.) fully set forth the differences between the typical graptolite shales of the Appalachian troughs (Schaghticoke, Deep Kill, Normanskill shales) and the black graptolite shales of the Mohawk valley. While the former are as a rule but relatively thin intercalations of black shales in grit and limestone beds, and great masses of gray, red and green shales, the black graptolite shales of the Canajoharie, Utica,

Deer River, Atwater and Lower Lorraine (Whetstone Gulf and Frankfort beds) are uninterrupted successions of black shales, reaching a thickness of 700 feet in the Utica shale and over 1200 feet in the Canajoharie shale.

Further it was shown that there is an important difference found in the composition of the shales, the typical graptolite shales of the Appalachian troughs being purely argillaceous, while those of the Mohawk valley possess a strong admixture of calcareous matter.

The most important difference, however, is to be seen in the faunal assemblages of the two groups of graptolite shales. The typical graptolite shales of the first group have furnished a large graptolite fauna in many successive zones, but utterly lack other fossils. In all the thousands of feet of the combined Schaghticoke, Deep Kill and Normanskill shale but nine fossils, other than graptolites and the eurypterids of Catskill, have been found by me and all, almost without exception, only as extremely rare fossils. These fossils are:

Graptospongia pusilla Rued. a sponge of the Normanskill shale
Paterula amii Rued.
Schizotreta papilliformis Rued.
Leptobolus walcotti Rued.
Lingula quebecensis Billings
Eunoa accola Clarke
Serpulites interrogans Rued.
Caryocaris wrightii Gurley
C. curvilatus Gurley

The eurypterids found in the Normanskill shale at Catskill (N. Y. State Mus. Mem. 14, p. 413 ff.) are:

Eurypterus chadwicki C. & R.
Eusarcus linguatus C. & R.
Dolichopterus breviceps C. & R.
Stylonurus modestus C. & R.
Pterygotus ? (Eusarcus) nasutus C. & R.
P. normanskillensis C. & R.

These eurypterids occur intermingled with the graptolites. It will be seen that the nongraptolitic biota, extremely meager as it is, still represents important elements of the much larger one of the black graptolite shales of the Mohawk valley, namely, the sponges, phosphatic-chitinous inarticulate brachiopod shells, all very minute with the exception of the gigantic Lingula quebecensis and Eunoa accola, Clarke (probably a Discinocaris comparable to the British D. gigantea), the worms, phyllocarids[1] and eurypterids.

[1]The phyllocarids (Caryocaris) are found in great numbers on some bedding planes, not only here but also especially in British Columbia, Nevada and Quebec and are the same species in all these regions.

The writer has considered (N. Y. State Mus. Bul. 258, p. 82) these common nongraptolitic elements of the faunas of the calcareous and noncalcareous black shales as the nektonic, planktonic and pseudoplanktonic portion, the latter attached to seaweeds that drifted into the basins or grew along their margins; and has arrived at the conclusion that while the typical graptolite shales of the Appalachian region were deposited in the dead grounds of the deeper littoral zone (*ibid.* p. 81) of narrow troughs, carried there by the undertow of storms, the black graptolite shales of the Mohawk valley with their larger nongraptolitic faunas, more or less calcareous admixture and thick continuous deposition do not indicate conditions so utterly uncongenial to bottom life though still unfavorable. "This condition is principally due to the influx of the black mud, for in the transitional beds (Dolgeville beds) richly fossiliferous limestone beds alternate with fairly barren black shale bands." We inferred (*ibid.* p. 83) that the Canajoharie and Utica shales were deposited in seas of broader expanse, the Utica sea especially having extended far to the west. They had their shore lines in the east and northeast where the Schenectady beds exhibit many signs of shallow origin, while toward the north and northwest the Utica shale is replaced by the Cobourg limestone. While the black mud of the Canajoharie shale, which is replaced rapidly westward by the Trenton limestone, may be also due to the action of the undertow, the wide westward extension of the Utica shale was considered (p. 84) as calling for a further agency of wider geographic influence than the undertow and this was found in the presence of marine currents in the epicontinental Utica sea. Local thick accumulations of black Utica shale, as that around Utica, amounting to 700 feet of shale, suggest local sinking basins or depressions southwest of Adirondackia. In these basins conditions of more severe stagnancy may have developed at times, as suggested by the complete barrenness of some beds and the presence of iron pyrites.

While the extremely meager fauna of the typical argillaceous graptolite shales of the Appalachian troughs was considered as entirely foreign to the bottom grounds where the shale was deposited and as wholly derived from the higher levels of the water, the much larger biota of the Utica and associated shales, amounting to 108 forms in our list, were in Bulletin 258 considered as partly composed of foreign elements and partly of an impoverished bottom fauna of small pelecypods, gastropods, cephalopods, trilobites etc.

Our analysis of this larger fauna here carried out has shown, however, that this fauna is entirely different from that of the shore

formations, represented by the gray shales, sandstones and limestones. The sessile benthos as represented by the corals, crinoids and bryozoans is either entirely absent or, as in the case of the bryozoans, mainly represented by forms attached to shells of other vagile species. The sponges are an exception and their occurrence in closely crowded, well-preserved and fairly well spaced colonies indicate their former sessility on the bottom and their preservation *in situ.* The small types of phosphatic brachiopods, of pelecypods, gastropods and cephalopods, all with relatively thin shells, as well as the trilobites, may have belonged partly to the vagile benthos and partly been nektonic, planktonic, or pseudoplanktonic, living on and between floating seaweeds. The prevailing forms of trilobites, the species of Triarthrus and Cryptolithus, were undoubtedly bottom dwellers and mud grovellers. The phyllocarids found hiding in the paragastral cavity of a sponge were clearly also members of the vagile benthos and the eurypterids belonged partly to the vagile benthos and were partly pelagic. There is hence no doubt that the graptolite shales of the Utica type, in contrast to the typical graptolite shales of the Appalachian region, were deposited in depths that allowed specially adapted life, consisting of hexactinellid sponges; worms; a few bryozoans; small brachiopods with phosphatic, nonarticulating valves; small, often thin-shelled pelecypods; gastropods and cephalopods; small, mostly mud grovelling trilobites; primitive, minute ostracods; some phyllocarids and eurypterids.

The nature of this fauna supports the view attained before by the writer from the lithologic, stratigraphic and paleogeographic evidence, that the Utica shale and similar graptolite shales were deposited in the deeper reaches of more widely expanding epicontinental seas where there was plentiful influx of mud but still sufficient oxygen to allow a depauperated microfauna to exist, while in the typical graptolite shales no bottom life seems to be preserved.

At the same time that these conclusions with the exception of the analysis of the Utica-fauna were published, there appeared a most important contribution to the discussion of the problem of the graptolite shales by one of the pioneers of British graptolithology, T. E. Marr under the title The Stockdale Shales of the Lake District (Quart. Jour. Geol. Soc. v. 81 pt. 2, p. 113–33, July 4, 1925). This paper attacks the problem mainly from the side of the lithogenesis and stratigraphy of the rocks.

The great series of Silurian graptolite shales consists throughout of fine-grained material. The normal and principal deposits of the

period are green beds; besides these are found black to gray graptolite-bearing mudstones, blue nongraptolitic beds and red beds. This is a combination that we have typically in the Normanskill shale, with the addition, however, in the latter, of coarse grit beds and the Rysedorph hill conglomerate. Dr R. H. Rastall, who examined the different Stockdale shales, found that the mechanical basis of all these shales is the same, that the prevailing green muds are due to chloritic products derived from rocks of igneous and metamorphic character which furnished the material. The blue graptolite-shales contain 6 per cent to 11 per cent of carbon as coloring matter; the blue muds owe their color to the presence of iron carbonate, to the absence of free carbon and to the paucity of iron sulphide; the red beds are colored by iron oxide.

The vertical sequence is of great importance. It was found that the dark graptolitic muds predominate below, then follow the blue, thirdly the green, and lastly the red muds.

"The beautiful state of preservation of the delicate graptolites, is belong the graptolites, which by Lapworth and Ruedemann are were those of quietness of the floor; and this view is borne out by the preservation of the extremely thin tests of the Cephalopoda and the organisms referred to the Phyllocarida belonging to the genera Aptychopsis, Peltocaris and Discinocaris."

The fauna is divided into the plankton, in a general sense, or the organisms living near the surface and the benthos. To the former belong the graptolites, which by Lapworth and Ruedemann are considered as largely pseudo-planktonic and partly truly planktonic, the Phyllocarida and Cephalopoda and the problematical Dawsonia (also a constituent of the New York fauna). "The actual or presumed benthonic creatures of the Stockdale shales are distinguished by their dwarf size" and in the case of dark graptolite-bearing muds normal benthonic forms are practically absent. H. A. Nicholson and Marr had already shown in 1888 (The Stockdale Shale, Quart. Jour. Geol. Soc. v. 44, p. 654–732) that the Stockdale shale becomes coarser upward and especially eastward, suggesting an approach of the land margins toward the area under consideration in the latter part of the period, and during the same period lying in an easterly direction.

"As the quiet conditions which marked the deposition of the sediments can not be regarded as due to their formation in abysmal depths, embayments from the main ocean suggest themselves at once." Miss G. L. Elles D. Sc., has plotted upon a map of Europe the places of occurrences of the Stockdale shales or their equiva-

lents, and we copy here this interesting sketch map. It shows two deep gulfs extending from the Atlantic ocean across Great Britain into Scandinavia and middle Europe (see text figure 1). The shore lines are marked by a fringe of coastal deposits which are not shown on the map.

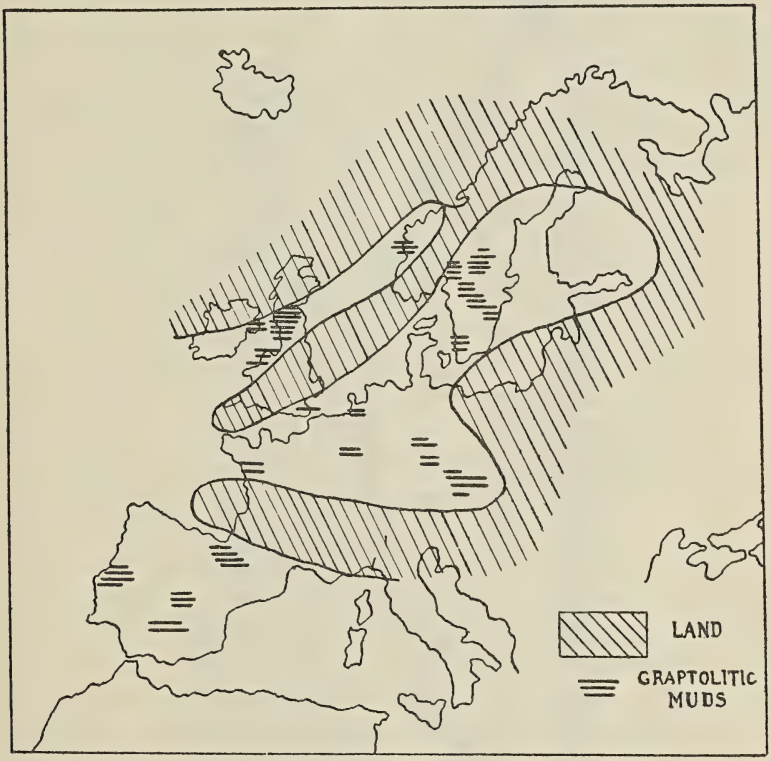


Figure 1 Sketch map showing localities in Europe and the British Isles where the Stockdale shales or their equivalents were deposited. (After J. E. Marr)

"In the quiet waters of such gulfs the fine sediments of the Stockdale shales and their equivalents might well be formed and the floating vegetation collected." The frequent and sudden appearance and disappearance of this algae material, regarded as the coloring matter of the black graptolite shales, is considered a matter of great importance. It is to some extent rhythmical and the most reasonable explanation, in Doctor Marr's view, is that it was due to change in direction of the sea currents which at times carried the weeds into the embayments, and at other times failed to do so.

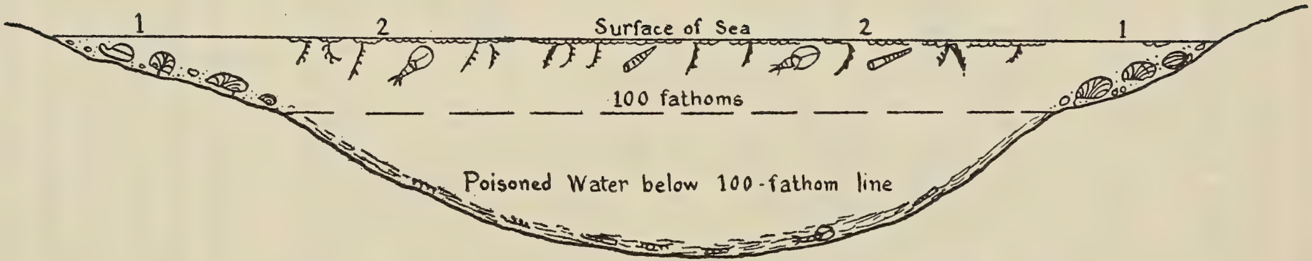


Figure 2 Diagram representing the conditions which prevailed during the deposition of dark graptolitic muds. (After J. E. Marr)

1 equals littoral deposits containing large and abundant benthonic forms. 2 equals algae, with pseudo-planktonic graptolites, also planktonic Cephalopods and Phyllocarida. Below lifeless sea bottom with black muds, wherein dead planktonic and pseudo-planktonic organisms, which have sunk from the surface waters, are entombed.

"The dwarf benthonic fauna is most important in the blue beds and parts of the red beds, very sparse in the green beds, and practically absent from the dark graptolitic beds. The general paucity of the benthonic fauna and the dwarf nature of the animals is not due to the muddy habitat, for there are similar muddy sediments in deposits of many ages containing abundance of benthonic life. The explanation is found in the view that conditions of stagnation arose in the deeper and quieter parts of the embayments causing the lower waters to be charged with deleterious substances" which for convenience are spoken of as poison. During the accumulation of the dark graptolitic muds this was fatal to benthonic life, it was only moderately harmful when the blue muds were laid down. The bottom conditions of the Black sea, already frequently referred to in connection with the black shales, are cited and the fact is emphasized that bacteria flourishing on the decomposing organic matter that is dropping into the depths from the plankton of the surface waters produce sulphuretted hydrogen which poisons the lower waters. The analogy, however, is not pushed to such an extent that landlocked water straits are inferred for the deposition of the Stockdale shales, but it is rather suspected that in that "age of algae" these plants played a more important part in geologic operations than at the present day.

An excellent diagram, here copied in text figure 2, illustrates the conditions as seen by Marr. It shows the coastal belt with its abundant benthonic fauna, the plankton and nekton of the surface waters (consisting of graptolites, phyllocarids and cephalopods), and the dead grounds below the 100 fathoms line (simply taken over by comparison with the conditions prevalent in the Black sea) where the black graptolite muds form.

It is finally shown that "the graptolitic muds are more fully developed in the more open tracts of the middle and southern gulf than in the narrower northern one. In Bohemia and other places of the middle gulf, the dark graptolitic muds were deposited in a succession almost unbroken (being interrupted only by the formation of thin green streaks) from the beginning of Valentian to the end of Wenlock times, and in a modified degree during Lower Ludlow times also. In other words, the narrow gulf of the north seems to have been to some extent inimical to the formation of the dark graptolitic muds, which are there largely replaced by the blue, green and red muds. To these latter alone, the narrow gulflike conditions appear to have been important."

We find the conditions so well described by Marr completely

duplicated in the graptolitic shales of New York. The narrow "Levis trough" in which the Schaghticoke shale, Deep Kill shale of early Ordovician or Canadian and the Normanskill shale of middle Ordovician age were deposited, contains, like the northern gulf of Great Britain, a great mass of green, bluish gray and red shales and of grits with rather sparsely interbedded black graptolite shales.

Figure 3 Lower Canadian (Bretonian) epicontinental seas. (After Ulrich)

The most recent paleogeographic chart of Canadian time in North America, here copied from Ulrich (Cambrian and Silurian, Geol. Survey of Maryland, 1919), brings out distinctly this narrow channel of the northeastern portion of the continent, which later in Normanskill time extended much farther south.

On the other hand, the Canajoharie and Utica graptolite shales of Trenton and post-Trenton time extended far to the north and south in the case of the Canajoharie shales and far to the west and northwest in the case of the Utica shale. The chart of the Utica sea, here copied from Ulrich (which included also the northern Colling-

Figure 4 Early Cincinnatian (Utica) epicontinental seas. (After Ulrich)

wood invasion), gives the conception of that sea attained by recent work. The paleogeography of the Utica sea in New York with its shore line in the east and deposition of limestone in the northwest, is copied here from Bulletin 258 of the State Museum.

Figure 5

The Canajoharie and Utica shales by their composition of uninterrupted black graptolite shales in successive zones and with their great thickness duplicate the conditions of the graptolite shales in the middle and southern gulfs of Europe, such as are typically shown in the Silurian shales of Bohemia.

We are greatly pleased to find that Professor Marr's final conclusions, reached after a lifelong study of the graptolite shales of Great Britain and of Europe in general, fully agree with ours elaborated in a series of papers in regard to the Canajoharie shale (N. Y. State Mus. Bul. 162) the Schaghticoke, Deep Kill and Normanskill shales (N. Y. State Mus. Bul. 169 and 227–28) and the Utica shale (N. Y. State Mus. Bul. 258). We also hope that this incontrovertible evidence from two continents will conclusively answer the claims of our friend, Professor A. W. Grabau, and his pupil that the graptolite beds are delta deposits and resting on the top of anticlines as in the diagram lately reproduced in the Stratigraphy of China (1923–24, p. 60). On the contrary, we feel, on seeing the graptolite shales of Europe represented as deposited in the deeper reaches of long persisting embayments extending northeast in the direction of the later Caledonian folding (especially so in the case of the northern embayment), that the assertion made in the monograph of the graptolites of New York (N. Y. State Mus. Mem. 11, p. 65) that the graptolite shales were largely deposited in geosynclines, may after all not have been so wrong as letters from some of our correspondents and certain notes in the literature would have it.

Devonaster eucharis (Hall) var. goldringae nov. Holotype x2. Photograph of mold reversed.

A DEVONIAN STARFISH FROM GASPÉ

By Rudolf Ruedemann

The late Dr John M. Clarke had in the splendid fauna which he secured in the Gaspé region of Quebec, Canada, and described so well in the Early Devonic of New York and Eastern North America (N. Y. State Mus. Mem. 9, 1908), only a single echinoderm, a poorly preserved specimen described as Melocrinus micmac. It aroused therefore his greatest interest when Winifred Goldring in 1922 brought a well-preserved specimen of a starfish from the Middle Devonian (*fide* Clarke) sandstone of the neighborhood of the Fourth Lake brook section near Fourth Lake, Gaspé county. He turned the specimen over to me for study and intended to publish a note regarding it.

Unfortunately only the abactinal (dorsal) side is preserved in the specimen. It would therefore be unwarranted to describe this form as a new species, if it were such, but a comparison with Devonaster eucharis (Hall) of our Hamilton shale which was suggested at first sight, brings out the fact that it quite probably would not prove to be a new species, even if the actinal side were preserved, but appears as only a variety of Devonaster eucharis as indicated by the abactinal side.

The specimen is not more than half the size of mature individuals of the New York form (measuring 12 mm. from the apex to the tip of an arm), but compared with individuals of its own size the radials are found to be relatively larger, especially broader (rectangular instead of squarish in top view as in D. eucharis), numbering about 14 in the middle column, while the typical D. eucharis of the same size has about 18. There are no accessory plates seen on the arms and the surface of the radials and supramarginals is smooth or nearly so instead of being pustulose as in typical D. eucharis. We propose to distinguish this well-marked geographical variety as Devonaster eucharis var. goldringae.

Restoration of the Fossil Forests of Gilboa.

NEW MUSEUM EXHIBITS

By Winifred Goldring

The Fossil Forests of Gilboa

The restoration group, shown in the accompanying plate, was formally opened to the public on February 11, 1925. This piece of work was executed by the artist and sculptor, Henri Marchand, and his two sons, Georges and Paul, under the supervision of the writer.

The restoration of the Gilboa tree and a full description of the material collected may be found in a paper by the writer, The Upper Devonian Forest of Seed Ferns in Eastern New York, published in New York State Museum Bulletin 251 (18th Report of the Director of the State Museum). The first material was found at Gilboa in 1869 when a freshet in the valley of the Schoharie creek exposed in the bedrock standing stumps of fossil trees. These fossil trees were described by Sir William Dawson of Montreal, but there was not enough material found at the time to enable him to place the trees accurately. Loose stumps from a higher horizon were reported in 1897 when Professor Charles S. Prosser, then connected with the New York State Survey, was working in the Gilboa area. All further efforts to relocate the Schoharie forest or to find some additional evidence of its extent were fruitless until the summer of 1920. Since 1920 the city of New York has been doing construction work on a dam at Gilboa; and through the courtesy of the Board of Water Supply and the various engineers connected with the work, together with zealous collecting by members of the Museum staff and others, much new material has been obtained, including seeds, foliage, roots etc.

It was not, however, until June 1922 that the writer had at hand material enough to enable her to identify these trees correctly and to attempt a restoration. The trees were found to belong to the Pteridosperms, or seed-bearing ferns, and are the earliest geological record (Upper Devonian or late Middle Devonian) of the seed-bearing habit. To these trees was given the name Eospermatopteris, from the Greek, meaning dawn of the seed fern (*eos*-dawn; *sperma*-seed; *pteris*-fern). Fossil tree stumps were found at three different horizons, the second 60 feet above the first, the third 100 feet above this. There were then three successive forests of trees which were ultimately destroyed by the sea and buried. The Gilboa forests grew along the low shores of the western Catskill mountain region,

facing the interior sea which at that period covered all of central and western New York. They grew in marshes which were easily covered by the rise of the tides and their bulbous bases with the long straplike roots anchored them in the soft black muds.

The restoration shows in the foreground an idealized reproduction of the rock section at Gilboa. The three fossil tree horizons are shown, and here the actual fossil stumps are used. In the middle foreground is a representation of the Schoharie creek with a side stream joining it at the left in a series of falls, as is seen in reality in one of its tributaries, the Manorkill. The background is a visualization of the forest as it might have appeared growing along a swampy shoreline in Devonian times. In front of the painting, at either side, are actual life-sized restorations of these seed ferns. Among the fern trees are occasional Protolepidodendrons, (lycopod types) similar to the " Naples tree," a restoration of which has stood for many years in the Museum.

"What is a Fossil?"

It has been the policy of the State Museum to make its exhibits intelligible and interesting to the general public, and this has been especially a problem in the Hall of Invertebrate Paleontology. With this in mind, restoration groups and explanatory cases are being introduced among the fossil exhibits. Of this latter kind are the two cases explaining " What is a fossil? ", planned to give the unscientific visitor a background which will allow him to study the fossil exhibits with more understanding.

A label with a full, but simplified, definition of a fossil is placed at the top of one case. This case shows examples of all the different ways in which a fossil may be preserved. Likewise in this case is a series of specimens showing various stages in fossilization from loose shells on a sea beach or river bank through loosely consolidated to completely cemented fossil-bearing rocks. Examples of the effect of partial and complete weathering on fossil-bearing rocks are also shown. Clay concretions, often mistaken for fossils because of their odd shapes, likewise have their place here, as well as pseudofossils which are of inorganic nature—either stains from decaying vegetable matter or branching mineral incrustations often mistaken by the uninitiated for fossil mosses or ferns.

The second case has various illustrations of the preservation of organisms according to their original composition. Here are shown the effect of conditions of preservation upon the original form, also

fragmentary preservation and the distortion of fossils by movements of the rock beds in which they are preserved. In this case belongs also the explanation of types, models, restorations, "squeezes" of various kinds, thin sections, natural and polished sections which are so often seen in fossil exhibit cases and not always comprehended.

Very full explanatory labels accompany all the examples; but for those who wish to spend less time there are subheadings with the specimens which with the full title label permit them to gain something from these cases with a quick survey.

The results obtained from these two cases have been very gratifying. They have attracted wide attention not only from the general public but also from scientific visitors.

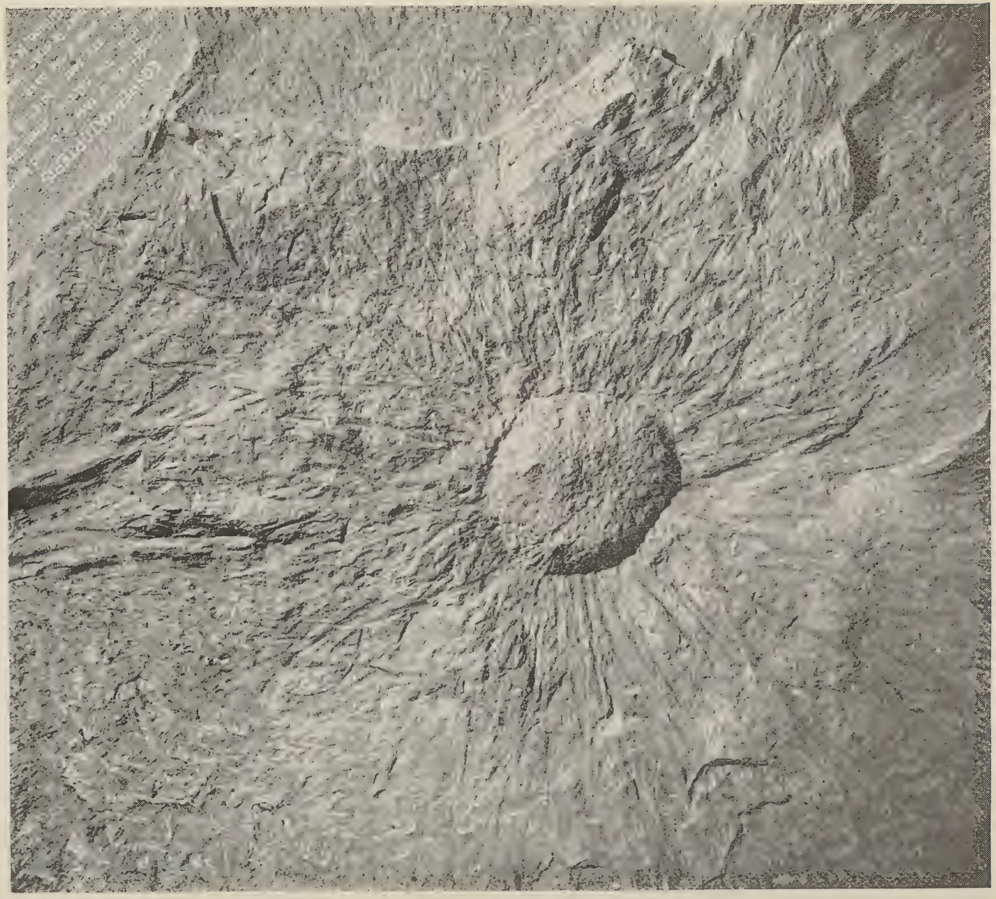
"What is a Geological Formation?"

This exhibit was planned as a companion to the "What is a Fossil?" exhibit and serves a similar purpose. It has been placed near the entrance to the Hall of Invertebrate Paleontology at the beginning of the series of synoptic cases, and has already attracted considerable attention.

The case was designed to give a better understanding of the meaning of a geologic formation. On top of the case is a title label giving a comprehensive and understandable definition of a geological formation, and in the case is a large, very full explanatory label. Six geologic maps of the State are shown. One map gives the surface distribution of the rocks of all the different ages. Each of the other five maps shows one of the important divisions: the present outcrop of the rocks of that age; the former extent of the rocks, which erosion has decreased; and the extension of these rocks southward under the younger beds. Five cross sections made through different parts of the State show the under surface conditions: the relations of the beds of the different ages, their general slope and thickness. A geologic column is used to show in more detail the succession from the oldest to the youngest beds in the eastern and western areas.

A plate of drawings of a few characteristic fossils has been made for each age. The visitor is referred to the synoptic cases where are displayed the actual fossil specimens of these and other species, and also outcrop maps of the various formations and maps showing the configuration of North America at each stage.

Colored photographs of typical exposures of the rocks of the different formations add to the attractiveness and instructive value of this case. These photographs are colored in oil so that there is no danger of fading. The museum draughtsman, E. J. Stein, has made a specialty of this oil coloring, and it will be possible for any museum to obtain photographs if desired.



Eospermatopteris. Underside of base showing radiating strap-like roots. Slab 5 feet, 7 inches by 6 feet, 4 inches.

NEW UPPER DEVONIAN PLANT MATERIAL

By Winifred Goldring

Eospermatopteris (seed fern) Material

Base with roots. After the earlier notices with regard to Eospermatopteris, the Upper Devonian seed fern, were published, some doubt was expressed as to the trees having grown in the place where they were found (Gilboa, Schoharie county), because stump after stump was taken from the quarry with no roots attached, although slabs of rock were found with detached roots, nor was it quite understood how the roots were attached. In the spring of 1923, while collecting at Gilboa, the writer by the merest chance came upon a large slab near the top of one of the dumps showing the underside of a tree base with long, radiating, straplike roots attached along the margin. The specimen was obtained under difficulties and set up in concrete to form a Museum exhibit, through the kindness of Henri Marchand who was then working on the Gilboa restoration group. The slab, as exhibited, measures 5 feet, 7 inches by 6 feet, 4 inches. The base of the stump is about 14 inches in diameter, and the radiating roots, from one-half inch or less to about an inch in width, extend without termination as far as the rock is preserved. From a study of this and other specimens it appears that the roots were undivided. Much larger specimens were found in the quarry, after this specimen was obtained, with roots at least 9 feet long, but it was impracticable to get them out. The specimen shown is in sandstone, but other specimens were found on the dumps sometime later showing the impression of the root base in the shale bed beneath the sandstone, often with the radiating roots well shown. The shale bed which nowhere is of great thickness, as pointed out in the fuller paper on these trees (N. Y. State Mus. Bul. 251), represents the muds in which the trees grew.

A photograph of the slab showing the tree base with its roots, as it is now exhibited in the Museum, is shown on the accompanying plate.

Petiolar scars. Hitherto specimens of stumps and trunks found at Gilboa have lacked the bark or, where the outer surface was shown, it was on the lower parts of stumps where no markings were distinguishable. This past summer three specimens were brought in by a local collector, R. Veenfliet jr, of Schoharie, N. Y., showing large, rounded scars, spirally arranged on a bit of the outer surface of a trunk, or scattered. With these scars in two

specimens is shown a portion of outer cortex with anastomosing, strengthening strands of schlerenchyma, as in the outer cortex of Eospermatopteris. After much study and comparison with other forms the conclusion has been reached that these spirally arranged markings are the scars marking the place of attachment of petioles of the large fronds of the tree fern, Eospermatopteris. The scars probably came from a young tree or from the upper portion of a larger trunk, for it is doubtful that the scars would be so distinct on the lower part of the older trunks, and they would, without question, have been more stretched apart as the result of elongation and increase in girth.

The two accompanying photographic plates show well the character and arrangement of the scars. One photograph shows also a piece of a Protolepidodendron branch. The occurrence of this species has already been recorded. It has been found sparsely in the beds containing the tree fern material and, while it has not yet been worked out, appears to be a different species than P. primaevum (Rogers) — our well-known "Naples tree."

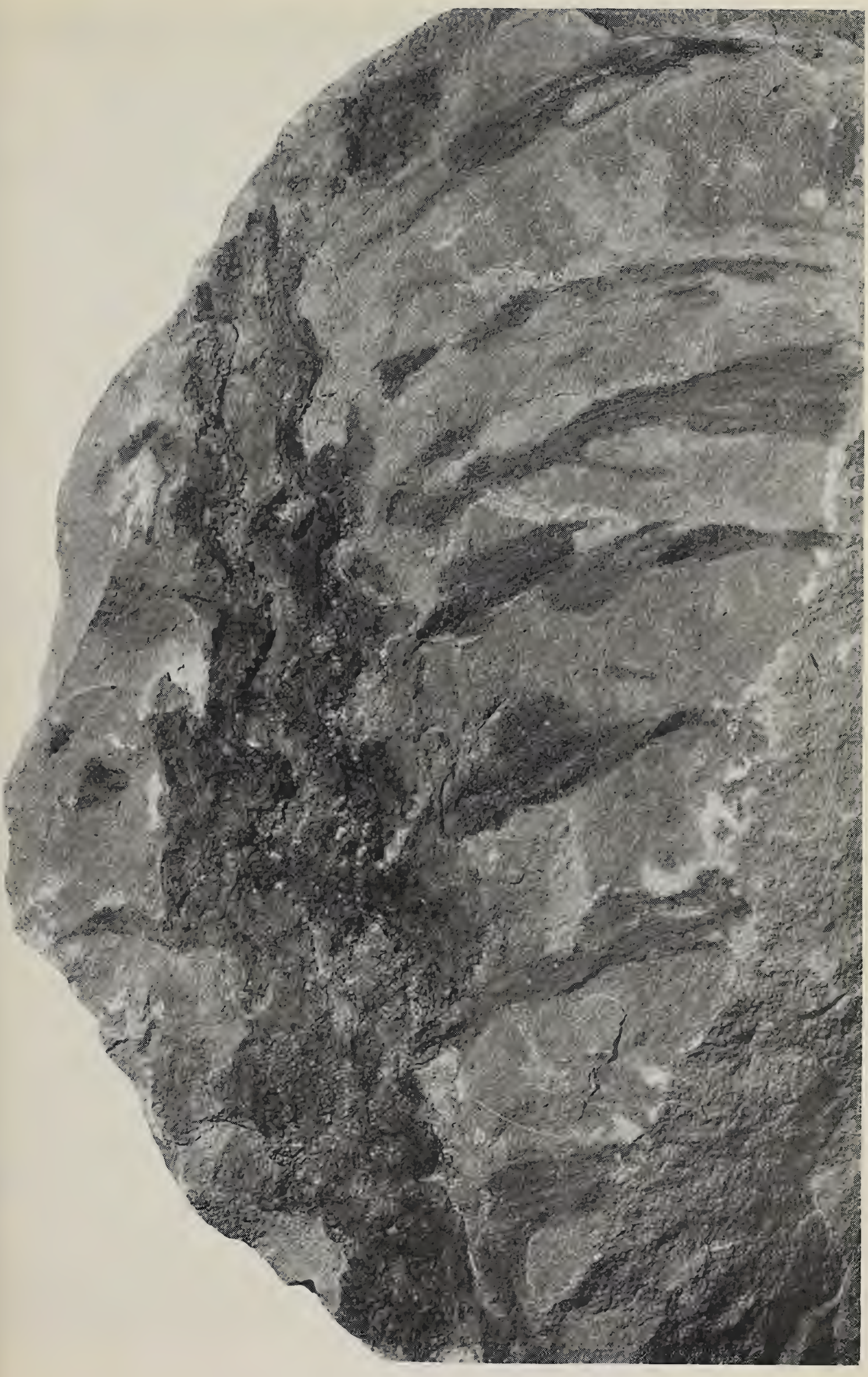
Lepidophyte Material

Rootlike organ. This specimen, figured in the accompanying photographic plate, was found loose along the edge of one of the big dumps at Gilboa and is the only specimen of the kind that has so far been obtained. It has every appearance of being part of a rootlike organ of a lepidophyte (lycopod-like plant). The root systems of plants of the Lepidodendron, Bothrodendron and Sigillaria groups were alike in that there was no tap root but the trunk passed down into regularly forked and spreading arms or rootlike organs (Stigmariae), bearing spirally disposed, long and slender rootlets. We have already recorded the occurrence of Protolepidodendron remains in the Upper Devonian beds at Gilboa and very recent collecting has brought to light a new species of apparent Sigillarian nature. This rootlike organ probably belongs to one or the other of these two lepidophytes.

Sigillaria (?) gilboensis sp. nov. This new species was added to our collection in the late fall of 1925 through the courtesy of Luther Dennis, superintendent with the Hugh Nawn Contracting Company. Only four specimens have been found, so far as is known, and three of these are in the possession of the State Museum. The best preserved specimen is shown in the accompanying photographic plate; the other two specimens are too poor for photographing and

Eospermatopteris. Specimen showing petiolar scars. Natural size.

Eospermatopteris. Specimen showing petiolar scars and some cortical tissue. About two-thirds natural size.



Sigillaria (?) gilboensis sp. nov. Portion of trunk with long grasslike leaves. About one-fourth natural size.

of little value for study. In the type specimen the trunk is 3 inches in diameter and a little more than 2 feet is preserved. The leaves are long and grasslike; they may reach a width of one quarter of an inch, but most of them measure less than this. None of the leaves has been found preserved to the full length, but specimens without terminations have been found 8, 9 and 11 inches long. In one of the other specimens the trunk likewise has a diameter of 3 inches; the diameter of the third trunk is between 4 and 5 inches.

As a general rule, leaves of lepidophytes were persistent for a comparatively short time on trunks, but they were more persistent in Sigillaria than in Lepidodendron, comparatively thick branches being found with attached leaves in the case of the former. It is possible that our specimen is a large branch rather than a trunk. It is also very likely that the leaves in this older form were persistent on the trunk for a longer time than in later species, just as in our "Naples tree," Protolepidodendron primaevum (Rogers), of the Upper Devonian the leaves were found to be persistent well down on the trunk. We have in this Gilboa form a new species which has been referred with a query to the genus Sigillaria until more material is available for study. It is possible that a new genus may have to be created for this form.

NEW SPECIES OF HAMILTON CRINOIDS

By Winifred Goldring

This crinoid material is part of that collected by G. Arthur Cooper in the Colgate University quarry in working out a problem for his master's thesis. The beds from which these specimens were collected are of Hamilton age, considered Ludlowville by Mr Cooper.

At first glance, without knowing the beds from which the specimens came, one might believe that one was dealing with an Ithaca-Chemung fauna, especially as regards the inadunate forms. It is quite evident that the Ithaca-Chemung type of crinoid fauna had already crept into these Hamilton beds. Two new species are represented. One has been found occurring in fair abundance, and to this the name Charientocrinus (?) cooperi has been given in honor of the collector; the other has been called Poteriocrinus (?) colgatensis. Of the two other species collected, one is a young specimen and has been identified with Gennaeocrinus carinatus Wood; the other is referred to Botryocrinus nycteus (Hall).

I am indebted to Mr Cooper for the opportunity of studying this material and for permission to retain the types and duplicate material for the State Museum.

Charientocrinus (?) **cooperi** sp. nov.

Plate 1, figures 1–3; text figure 1

This species belongs in the characteristic family Glossocrinidae with species of the genera Glossocrinus, Liparocrinus, Catactocrinus and Charientocrinus. C. cooperi bears a strong resemblance in general to the genotype, Catactocrinus leptodactylus Goldring; but the latter has arms that do not bifurcate, a different arrangement of the pinnules and the stem is not so cirriferous, especially in the proximal portion. The strongest affinities, so far as the present material shows, is with Charientocrinus ithacensis Goldring. The anal area in no specimen is well shown. For the time being the species is referred with a query to the genus Charientocrinus.

The dorsal cup in a typical specimen is about 3 mm high, with small, low infrabasals. The cup is ornamented with conspicuous folds or ridges. The posterior side is shown in one specimen, but not very clearly. The structure of the cup in this area is apparently that of Poteriocrinus, Decadocrinus etc., as is seen in all the genera referred to the family Glossocrinidae, and this species likewise has

the type of anal tube (Figure 1B) characteristic of the genera of this family. The latter is long and slender, in no place preserved for its full length. In one of the smaller specimens, the anal tube has a width of 2.6 mm in the proximal portion; only 16 mm of the tube is preserved and it tapers very little. The specimen from which the measurement of the dorsal cup was taken shows parts of the anal tube, which measures 2.8 mm in width more than half way from the proximal end, and even extends a little beyond the tips of the arms. The tube is shown in several specimens to be composed of rows of narrow plates, but only two specimens give any indication of the median, dorsal, armlike series of plates so characteristic of the genus.

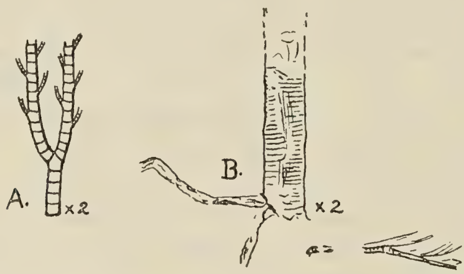


Figure 1 Charientocrinus (?) cooperi sp. nov. A. Proximal portion of an arm showing the arrangement of the pinnules, x2; B. Proximal portion of anal tube, x2.

There are five primibrachs, the fifth axillary, giving rise to two arms to the ray, ten to the crown. The arms are very long (over 51 mm) and slender, compared with the height of the dorsal cup, and bear very long, slender pinnules. The pinnules are borne alternately on each side on every second brachial, thus giving a space of four brachials between the pinnules on each side (figure 1A). The brachials are quadrangular and short, eight occurring in a space of 4.3 mm in the proximal portion.

The column is slender, pentagonal, not preserved for any great length, but bearing on the nodals, so far as preserved, very long slender cirri. The column is composed of alternating thin and thick columnals; the cirri-bearing columnals, the nodals, are close together.

This species differs from C. ithacensis in the fewer primibrachs, the arms not branching above the primibrachs, the more conspicuous folds on the plates of the dorsal cup and in the more cirriferous column.

Horizon and locality. Hamilton beds, Campus quarry, Colgate University, Hamilton, N. Y.

Poteriocrinus (?) colgatensis sp nov.

Plate 2, figures 1–6

This is a very characteristic species, but as the arm characters are missing it is referred with a query to the genus Poteriocrinus. It is so characteristic, however, that there could be no difficulty in identifying it. It is a large species with a heavy, pentagonal, cirriferous stem. The length of the crown is not known, but one specimen measures 65 mm from the base of the calyx to the distal portion of the anal tube, which is not fully preserved.

There are five large infrabasals measuring 2.7 mm in height. The total height of the cup is 9.8 mm. The cup must have been as broad or broader than high, but no measurements can be taken because of the flattened condition of the specimens. The plates of the anal area have the same arrangement as in the Poteriocrinus group. The radianal and anal x are both comparatively large, and so are the first tube plates. The anal tube is long and broad and composed of numerous rows of narrow plates. In one specimen it is preserved for a length of some 55 mm. The anal tube is at least 12 mm broad in its distal portion and 13.5 mm broad a short distance above the calyx.

The arms are not preserved more than one or two brachials above the primaxil in any specimen. There are four primibrachs, the fourth axillary. The first primibrach is much larger than the others; the proximal face measures 5.3 mm and occupies practically the entire upper face of the radial; the distal face measures 2.8 mm. It has a height of 3 mm. The primaxil has a height of 3 mm; the other primibrachs are about 2 mm high and 2.3 mm wide. The brachials following the primaxil are shorter and not so wide.

The calyx plates are ornamented with radiating ridges and depressions at the corners of the plates. There is a spine 2.8 mm long on each primaxil and several about 3 mm long on the distal part of the anal tube.

The column is heavy and pentagonal, composed of nodes and internodes and bearing at the nodes two or three comparatively long, heavy cirri. The cirriferous nodes are quite close together, and the cirri are borne close to the calyx.

Horizon and locality. Hamilton beds, Campus quarry, Colgate University, Hamilton, N. Y.

EXPLANATION OF PLATES

Plate 1

Charientocrinus (?) **cooperi** sp. nov.

Page 89.

Figure 1 Specimen showing well the character of arms and column.

Figure 2 Counterpart of the same. The calyx is more distinct here.

Figure 3 Plasticene squeeze of specimen shown in figure 2.

Plate 2

Poteriocrinus (?) **colgatensis** sp. nov.

Page 91.

Figure 1 Cast of part of a crown. The spines of the anal tube and primaxil are well shown; also the character of the column.

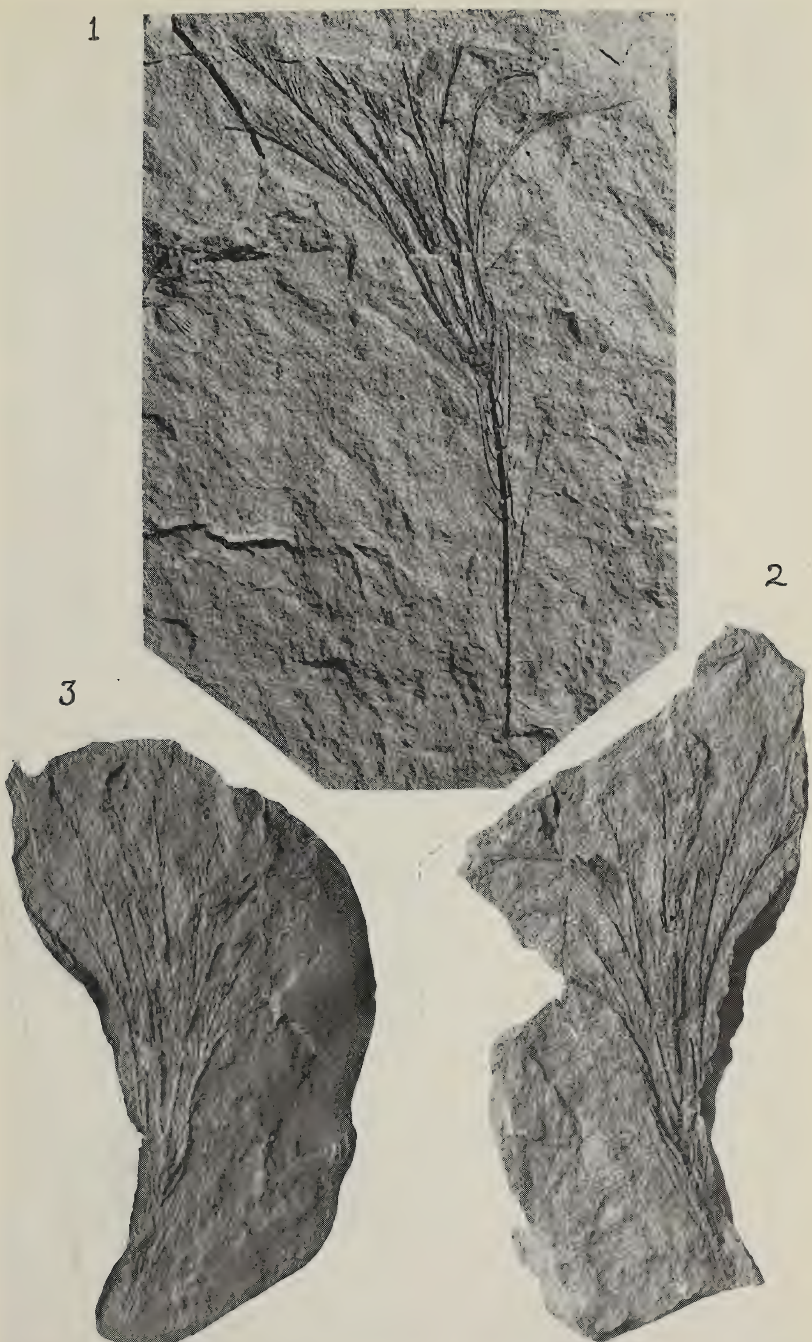
Figure 2 Plasticene squeeze of the dorsal cup and primibrachs of the same specimen. The ridges on the plates of the dorsal cup are quite distinct.

Figure 3 Cast of portion of dorsal cup of another specimen. Note the length of the spine on the primaxil.

Figure 4 Plasticene squeeze of another specimen showing the anal area (at left).

Figure 5 Internal cast of calyx and proximal portion of anal tube.

Figure 6 Portion of a column with cirri.



J. A. Glenn & E. J. Stein photo.

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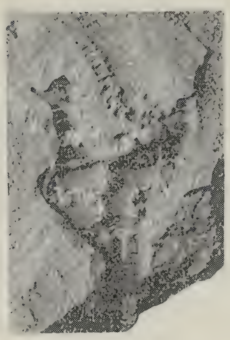

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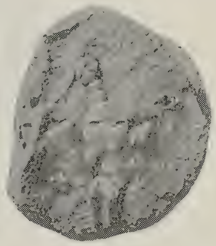

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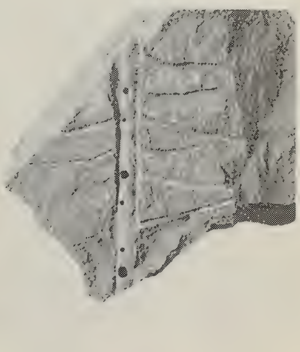

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New York State Museum

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These reports are made up of the reports of the Director, Geologist, Paleontologist. Botanist and Entomologist, and museum bulletins and memoirs, issued as advance sections of the reports.

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These reports cover the reports of the State Geologist and of the State Paleontologist, Bound also with the museum reports of which they form a part.

Geologist's annual reports 1881–date. Rep'ts 1, 3–13, 17–date, 8vo.; 2, 14–16, 4to.

In 1898 the paleontologic work of the State was made distinct from the geologic and was reported separately from 1899–1903. The two departments were reunited in 1904, and are now reported in the Director's report.

The annual reports of the original Natural History Survey, 1837–41, are out of print.

Reports 1–4, 1881–84, were published only in separate form. Of the 5th report 4 pages were reprinted in the 39th museum report, and a supplement to the 6th report was included in the 40th museum report. The 7th and subsequent reports are included in the 41st and following museum reports, except that certain lithographic plates in the 11th report (1891) and 13th (1893) are omitted from the 45th and 47th museum reports.

Separate volumes of the following only are available.

Report	*Price*	*Report*	*Price*	*Report*	*Price*
12 (1892)	*Out of print*	17	$1.00	21	$.40
14	1.00	18	.75	22	.40
15, 2v.	2.50	19	[.50]	23	.45
16	1.50	20	.50	[*See* Director's annual reports]	

Paleontologist's annual reports 1899–date.

See first note under Geologist's annual reports.

Bound also with museum reports of which they form a part. Reports for 1899 and 1900 may be had for 20c each. Those for 1901–3 were issued as bulletins. In 1904 combined with the Director's report.

Entomologist's annual reports on the injurious and other insects of the State of New York 1882–date.

Reports 3–20 bound also with museum reports 40–46, 48–58 of which they form a part. Since 1898 these reports have been issued as bulletins. Reports 3–4, 17 are out of print. Other reports with prices are:

Report	*Price*	*Report*	*Price*	*Report*	*Price*
1	*Out of print*	14 (Bul. 23)	$.20	26 (Bul. 147)	$.35
2	$.30	15 (" 31)	.15	27 (" 155)	.40
5	.25	16 (" 36)	.25	28 (" 165)	.40
6	.15	18 (" 64)	.20	29 (" 175)	.45
7	.20	19 (" 76)	.15	30 (" 180)	.50
8	.25	20 (" 97)	.40	31 (" 186)	.35
9	.25	21 (" 104)	.25	32 (" 198)	.40
10	.35	22 (" 110)	.25	33 (" 202)	.35
11	.25	23 (" 124)	.75	34 (" 231–232)	.20
12	.25	24 (" 134)	.35	35 (" 247–248)	.40
13	*Out of print*	25 (" 141)	.35		

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Botanist's annual reports 1867-date.

Bound also with museum reports 21-71 of which they form a part; the first Botanist's report appeared in the 21st museum report and is numbered 21. Reports 21-24, 29, 31-41 were not published separately.

Separate reports for 1871-74, 1876, 1888-99 are out of print. Report for 1900 may be had for 50c. Since 1901 these reports have been issued as bulletins.

Descriptions and illustrations of edible, poisonous and unwholesome fungi of New York have also been published in volumes 1 and 3 of the 48th (1894) museum report and in volume 1 of the 49th (1895), 51st (1897), 52d (1898), 54th (1900), 55th (1901), in volume 4 of the 56th (1902), in volume 2 of the 57th (1903), in volume 4 of the 58th (1904), in volume 2 of the 59th (1905), in volume 1 of the 60th (1906), in volume 2 of the 61st (1907), 62d (1908), 63d (1909), 64th (1910), 65th (1911), v. 2 of the 66th (1912) reports. The descriptions and illustrations of edible and unwholesome species contained in the 49th, 51st and 52d reports have been revised and rearranged, and, combined with others more recently prepared, constitute Museum Memoir 4.

Museum bulletins 1887-date. 8vo. (1) *geology, economic geology, paleontology, mineralogy;* (2) *general zoology, archeology, miscellaneous;* (3) *botany;* (4) *entomology.*

Bulletins are grouped in the list on the following pages according to divisions. The divisions to which bulletins belong are as follows:

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2 Botany
3 Economic Geology
4 Mineralogy
5 Entomology
6 "
7 Economic Geology
8 Botany
9 Zoology
10 Economic Geology
11 " "
12 " "
13 Entomology
14 Geology
15 Economic Geology
16 Archeology
17 Economic Geology
18 Archeology
19 Geology
20 Entomology
21 Geology
22 Archeology
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66 Miscellaneous
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Geology and Paleontology. 14 Kemp, J. F. Geology of Moriah and Westport Townships, Essex Co., N. Y., with notes on the iron mines. 38p. il. 7pl. 2 maps. Sept. 1895. *Free.*

19 Merrill, F. J. H. Guide to the Study of the Geological Collections of the New York State Museum. 164p. 119pl. map. Nov. 1898. *Out of print.*

21 Kemp, J. F. Geology of the Lake Placid Region. 24p. 1pl. map. Sept. 1898. *Out of print.*

34 Cumings, E. R. Lower Silurian System of Eastern Montgomery County; Prosser, C. S. Notes on the Stratigraphy of Mohawk Valley and Saratoga County, N. Y. 74p. 14pl. map. May 1900. 15c.

39 Clarke, J. M.; Simpson, G. B. & Loomis, F. B. Paleontologic Papers 1. 72p. il. 16pl. Oct. 1900. 15c.

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—— Paropsonema cryptophya; a Peculiar Echinoderm from the Intumescens-zone (Portage Beds) of Western New York.

—— Dictyonine Hexactinellid Sponges from the Upper Devonic of New York.
—— The Water Biscuit of Squaw Island, Canandaigua Lake, N. Y.
Simpson, G. B. Preliminary Descriptions of New Genera of Paleozoic Rugose Corals.
Loomis, F. B. Siluric Fungi from Western New York.

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45 Grabau, A. W. Geology and Paleontology of Niagara Falls and Vicinity. 286p. il. 18pl. map. Apr. 1901. *Out of print.*

48 Woodworth, J. B. Pleistocene Geology of Nassau County and Borough of Queens. 58p. il. 8pl. map. Dec. 1901. *Out of print.*

49 Ruedemann, Rudolf; Clarke, J. M. & Wood, Elvira. Paleontologic Papers 2. 240p. 13pl. Dec. 1901. *Out of print.*

Contents: Ruedemann, Rudolf. Trenton Conglomerate of Rysedorph Hill.
Clarke, J. M. Limestones of Central and Western New York Interbedded with Bituminous Shales of the Marcellus Stage.
Wood, Elvira. Marcellus Limestones of Lancaster, Erie Co., N. Y.
Clarke, J. M. New Agelacrinites.
—— Value of Amnigenia as an Indicator of Fresh-water Deposits during the Devonic of New York, Ireland and the Rhineland

52 Clarke, J. M. Report of the State Paleontologist 1901. 280p. il. 10pl. map, 1 tab. July 1902. 40c.

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NOTES ON THE HABITS AND DEVELOPMENT OF THE MUDPUPPY

Necturus maculosus (Rafinesque)

BY

SHERMAN C. BISHOP

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NOTES ON THE HABITS AND DEVELOPMENT OF THE MUDPUPPY

Necturus maculosus (Rafinesque)

BY

Sherman C. Bishop

INTRODUCTION

The mudpuppy, Necturus maculosus (Rafinesque), has been known to science for more than a hundred years. It is one of the largest salamanders, widely distributed and extremely abundant in many localities. The life history, habits and development have been investigated by a number of workers and recently considerable attention has been given to experimental work in endocrinology. A review of the literature, however, reveals a lack of exact information concerning certain phases of development and growth and habits of both the young and the sexually mature.

The material and notes on which this study is based have been accumulated chiefly during the past 3 or 4 years but the mudpuppy has been an intimate acquaintance for a much longer period. The writer has collected the species in various parts of New York and northwestern Pennsylvania and has had for study some specimens from North Carolina and Canada. Altogether several hundred specimens have been handled. The abundance of the material used in determining the rate of growth and the age of specimens is revealed to some extent in the tables of measurements given in the body of the report.

This account is not concerned with the segmentation of the egg or with gastrulation and early formation of the embryo, although some references to the literature of these phases are included for the convenience of those interested. It deals particularly with the

late embryonic stages, the posthatching period of rapid development, the growth of the species to sexual maturity and the habits of both young and adults.

The writer is greatly indebted to Paul A. Webb of Meadville, Pa., for the use of much material not otherwise available to him, for help in collecting and measuring specimens and for much information concerning habits; to Professor Barnard S. Bronson of the State College for Teachers and Hugh P. Chrisp of Albany, N. Y., who made possible, by the generous use of their automobiles, many profitable field excursions. The drawings have been prepared by W. J. Schoonmaker, assistant to the Zoologist, and E. J. Stein assisted very materially by making several photographs.

THE DISTRIBUTION OF NECTURUS

The range of Necturus maculosus as established by Stejneger and Barbour[1], is as follows: "Tributaries of the Great Lakes, the Mississippi River system, the upper Hudson River, and Lake Champlain. Rivers of North and South Carolina, Georgia and Alabama."

HABITAT

The ability the mudpuppy has to exist in waters of extremely diverse character and to compete successfully with the enormous number of animals with which it is associated, accounts in large part for its wide distribution. The Great Lakes and their tributaries harbor them by thousands. They persist in certain of the Finger Lakes in New York in spite of intensive collecting over a period of many years. Not only are they found in the clear open waters of lakes and streams where the character of the bottom prevents plant growth, but also in shallow weed-choked bays and streams and in the perennially muddy and polluted waters of creeks, rivers and canals. They are common in the Hudson and Mohawk rivers near Albany and in the turbid Mississippi; in waters ice-bound months at a time and in the tepid streams of some of the southeastern states; in shallow, rapid streams with rocky beds and in deep, slow streams with mud banks and bottoms; and in canals, reservoirs and backwaters. In the north they are most numerous and reach their best development in clear streams and lakes.

The mudpuppy is not always found in the same part of a stream or lake at all seasons of the year. There is evidence of certain

[1] Stejneger, Leonhard and Barbour, Thomas. A Check List of North American Amphibians and Reptiles. Cambridge. 1923. 2d ed. p. 1.

movements or migrations which are controlled to some extent by the breeding habits; and the sexually mature animals are able to live where it is probable the young would not long survive. In muddy streams the species is known chiefly from adults taken by fishermen, the character of the environment precluding an intimate acquaintance with the eggs and larvae. It is probable that the adult females living in such a habitat find it necessary to move into shallower tributary streams for the egg-laying period. Even in clear streams some segregation occurs and the young ones are sometimes found in numbers where the adults are absent.

Necturus is so eminently successful in the clear tributaries of the Allegheny in northwestern Pennsylvania and the adjoining counties in New York that one of these streams, Woodcock creek in Crawford county, Pennsylvania, may be described somewhat in detail to present a typical stream habitat. The creek rises in the eastern part of the county and flows westward to join French creek near Saegertown. In its lower reaches it crosses wide meadows among low hills and the course is marked by many shallow riffles (plate 1). Over considerable stretches bedrock forms a pavement which is strewn with flat stones and small boulders. These areas alternate with the gravelly riffles and deeper pools of quiet water. Any large flat stone lying on the surface or partially imbedded may serve as a hiding place for the mudpuppy. Food is abundant. Crawfish, larvae and nymphs of aquatic insects, and small fish seek the shelter of the stones which often conceal Necturus. Earthworms are carried into the streams with every rain. Small mollusks occupy the crevices between the rocks and attach themselves to the lower surface of stones.

The mudpuppies are in competition with the common creek fishes, suckers, chubs and minnows of various species, and with Cryptobranchus which is present in considerable numbers. Among its enemies must be reckoned the older individuals of its own species which have become addicted to the egg-eating habit. Cryptobranchus also takes the eggs of Necturus but probably not in great numbers. Herons and crows frequent the shallows and may be expected to take the smaller individuals when opportunity offers. Small, white, parasitic worms attach themselves to the surface of the skin of the mudpuppy and leave their marks in the shape of irregular whitish patches which persist for a considerable time. Finally the water mold, Saprolegnia, attacks both eggs and animals.

GENERAL HABITS

The mudpuppy is preeminently aquatic notwithstanding the statements of Smith[1], DeKay[2] and Holbrook[3] that occasionally it comes out on land. Aquatic animals of any kind, even fishes, will sometimes rush out of the water and pay for the venture with their lives. It is essentially nocturnal in clear streams and shallow waters of lakes, but in muddy waters and in weedy streams and bays it is more or less active throughout the day. In the muddy Clyde river the writer has taken it at all hours while fishing with hook and line. In the early spring it is particularly voracious and is often taken by hundreds. Fishermen in general regard it as poisonous, and the usual procedure in freeing a specimen is to cut away the hook, crush the head of the beast and throw it on the bank to die. Milner[4] gives the following account:

A fisherman at Evanston, Ill., a few years ago had nine hundred hooks set in the lake, and in one day took from these five hundred lizards, removing them all himself, as his men, sharing the popular notion on the lakes, believed them to be poisonous and preferred to cut away hook and all to taking hold of the slimy amphibian.

In the fall the sexually mature are found in pairs and small groups in situations that offer good nesting sites for the females. The young of the year and a few older individuals may sometimes accompany them but not in considerable numbers. While the adults are on the breeding grounds the sexually immature may often congregate in the deeper waters of larger streams. Here they hide beneath the flat stones of the bottom, and individuals of all ages from 1 to 4 or 5 years may occupy the same retreat. In late August, 1925, in one of the larger tributaries of the Allegheny, young of various ages were found in water varying in depth from 18 inches to 2 feet; but not one adult was found at this locality during 10 days of active collecting. In the shallower waters of lesser tributaries the adults were occupying every suitable retreat.

Necturus is more or less active throughout the year; early writers, however, reported them only in certain seasons. Kneeland[5] remarks:

These animals are rarely if ever seen, except during the winter; those I obtained were sucked up through the pumps for the supply of the water for the copper stamps; they are never thus caught in the summer or autumn. They change their skin at this season; . . .

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[1] Smith, I. U. Isis. 1832. p. 1088.
[2] DeKay, J. E. Zoology of New York, pt. 3. 1842. p. 87.
[3] Holbrook, J. E. North American Herpetology, 2d ed. 1842. 5:113.
[4] Milner, J. W. Rep't U. S. Commission of Fish and Fisheries. 1874. p. 62.
[5] Kneeland, Samuel. Proc. Bost. Soc. Nat. Hist. 1857. 6:153.

The reason why they approach the shore at this season may be on account of this change in the skin and possibly for breeding purposes.

Holbrook[1] in his brief account of the habits says: "The Menobranchus maculatus is seldom taken, except in the months of April and May, which is their spawning season."

Morse[2] says: "The Mud-puppy may be found often under the ice in the coldest winters."

Food

The natural food of Necturus consists of fish, fish eggs, crawfish, aquatic insects and their larvae and worms. Hay[3] adds mollusks to the diet. In captivity earthworms and raw liver are sometimes eaten. The abundance of Necturus in lakes and streams and its habit of eating eggs marks it as an enemy of certain fishes. Milner[4] gives the following account which has been widely quoted:

Mr George Clarke, of Ecorse, Mich., had a minnow-seine fitted to the bag of a sweep-seine, and at one haul took two thousand of the "water lizards." Estimating the extent that the net passed over, he calculated the average number of lizards to each square rod to be four. He says, further, in one of the Detroit papers, "The lizards were so gorged with white-fish spawn that when they were thrown on the shore, hundreds of eggs would fly out of their mouths."

Locomotion

Mudpuppies swim with strong lateral undulations of the body, the legs being held against the sides. In walking or crawling over the bottom the diagonally opposite legs move together.

Respiration

In poorly aerated water or in water warmer than that to which the animal is accustomed, the gills are kept in constant motion. In clear, cold, well-aerated water they are often held motionless for long periods against the sides of the neck. Under such conditions the blood supply is restricted, the bright crimson fades to a dull ruby red and the animal is quiet. When the oxygen supply of the water is low the animal at frequent intervals rises to the surface, gulps in a mouthful of air and again sinks to the bottom. Part of the air thus obtained passes out through the gill clefts and the remainder, in some instances at least, is taken into the lungs. The skin also functions in respiration and is well supplied with blood,

[1] Holbrook, J. E. North American Herpetology, 2d ed. 1842. 5:113.
[2] Morse, Max. Proc. Ohio State Acad. Sci. 1904. 4:107.
[3] Hay, O. P. 17th Ann. Rep't Ind. Dep't Geol. and Nat. Res. 1892. p. 419.
[4] Milner, J. W. Rep't U. S. Commission of Fish and Fisheries. 1874. p. 62.

particularly in the region of the tail[1]. Judging by the actions of animals under the conditions outlined above, it seems probable that the skin alone may furnish the necessary oxygen in well-aerated water, that the gills are used under ordinary stream and lake conditions and that the lungs are called into service as a last resort.

When a living specimen is exposed to the air, complete drying of the skin is prevented for a considerable time by a copious production of slime which pours out of the dermal glands and completely envelops the body. The animal gasps for breath but in the course of a few hours dies, the lungs alone being unable to furnish sufficient oxygen. In water, however, the animal may live without apparent discomfort with the gill filaments entirely lost.

Reaction to Light

Reese[2] found that all parts of the body of Necturus were sensitive to light, the head especially when the light was directed from above. When the source of the light was below the body, the tail seemed to be the most sensitive. Eycleshymer[3], experimenting with decapitated larvae, found them negatively phototropic, particularly when the light was directed on the tail. Pearse[4] also found Necturus negatively phototropic, blinded as well as normal individuals responding to stimuli.

In aquariums both larvae and adults seek the shaded areas. In a large storage tank containing several hundred individuals it was possible to drive the specimens from one end of the container to the other by the use of an ordinary hand flashlight.

MATING HABITS

Those who attempt to pry into the intimate affairs of secretive animals find the way beset with difficulties. Necturus is no exception to the rule. Dawson[5] writing in 1922 says:

At present the mating habits of Necturus are not definitely known. Strong circumstantial evidence indicates (Kingsbury '95) that fertilization is accomplished by the deposition of spermatophores and the reception of the spermatozoa which are borne upon the summits of the deposited spermatophores into the cloaca of the female. The time and exact manner of insemination are not known. . . . . Al-

[1] Dawson, A. B. Jour. Morph. 1920. 34:517.
[2] Reese, A. M. Biol. Bul. 1906. 11:96.
[3] Eycleshymer, A. C. Jour. Comp. Neur. and Phychol. 1908. 18:303; Anat. Anz. 1914. 46:11.
[4] Pearse, A. S. Proc. Amer. Acad. Arts and Sci. 1910. 45:168.
[5] Dawson, A. B. Jour. Morph. 1922. 36:447.

though our information on the time and manner of fertilization is still incomplete, it seems highly probable that spermatophores are produced by the male Necturus.

The dissections of both Kingsbury and Dawson prove internal fertilization and strongly indicate an autumnal mating period. Fertilization might be accomplished either by direct transfer of sperms in a venter to venter copulation or by means of spermatophores deposited in water. Dawson[1] inclines to the view that spermatophores are deposited.

In Kingsbury's important paper[2], "The Spermatheca and Methods of Fertilization in Some American Newts and Salamanders," some results of studies of Necturus are given. Spermathecae in the cloaca of females collected in fall and winter were found to contain active sperms. The habits of Necturus were little known at the time, however, and it was impossible to determine whether the sperms were acquired in an autumnal mating without ovulation or had simply been held over after ovulation in spring or fall. It is now known that ovulation occurs in the spring, and evidence is here presented to show that autumnal fertilization is the usual procedure.

In the fall of 1922 or 1923, Paul A. Webb placed a pair of mudpuppies in a large aquarium. The male manifested considerable interest in the female and behaved somewhat after the manner of the male newt, Triturus viridescens. The female received the attentions, held herself erect by supporting the body on the hind legs and tail and made no attempt to escape. The male swam and crawled around the female and frequently passed over the tail and between the legs. This performance was continued for a considerable period. An actual venter to venter copulation was not observed nor were spermatophores noticed in the aquarium. Unfortunately no record was kept of the exact date of the occurrence. These observations indicate that courtship may be a mating procedure as in Triturus and others. In the case of the newt the eggs are laid in the spring following a strenuous courtship on the part of the male. In the fall the male newt again goes through his mating antics, develops the horny excrescences on the toes and thighs and deposits spermatophores; but, so far as known, the female deposits no eggs. With Necturus the autumnal mating alone takes place. The female newt tolerates the actions of the male in the fall, the female Necturus actively participates. There is no longer the need of a spring mating

[1] Dawson, A. B. Jour. Morph. 1922. 36:447.
[2] Kingsbury, B. F. Tran. Amer. Micros. Soc. 1895. 17:261–304. pl. 1–4, figs. 1–19.

and no evidence of it. When the females are on the spawning grounds males are rarely if ever found in the immediate vicinity. The vent of the male is swollen and inflamed in the fall; it is nearly normal in the spring. Eycleshymer[1] has called attention to the segregation of the females during ovulation in the following words: "During egg-laying the males are never found with the females and where they remain is unknown." Spermatophores are doubtless formed, but whether they are deposited as in Triturus viridescens, Ambystoma maculatum and other species or taken up in contact copulation has not been determined. I have often observed, in preserved specimens, that males taken in the fall have the vent filled with a clear gelatinous mass. This is sometimes extruded and hangs at the orifice of the vent. I have not found spermatozoa within the mass, however. Kneeland[2] as early as 1857 kept Necturus through the winter and observed at times the deposition of gelatinous masses. This is suggestive of the spermatophores of Ambystoma maculatum, particularly the clear basal parts on which the sperms are deposited in whitish masses.

THE EGG-LAYING SEASON

Water temperature plays an important role in initiating ovulation in any particular region. For this reason it is impossible to make general statements concerning the egg-laying period without a study of conditions in many widely separated regions and in waters of various character.

In shallow waters of streams and lakes the season may be much earlier than in deeper bodies in the same latitude. Other conditions being equal, the season should be earlier in the southern part of the range of the animal than in northern waters.

In northwestern Pennsylvania the egg-laying season begins early in June when the water temperature near the surface of shallow streams is about 74 to 78 degrees F.[3] In the nests themselves, usually shallow cavities beneath flat rocks, the temperature is probably a few degrees lower. In 1924 the first fresh eggs of the season were found on June 5th. In 1925, June 5th again marked the beginning of ovulation and fresh eggs were found as late as June 11th. Eggs deposited June 5th began to hatch July 13th, a period of incubation of 38 days. The period of incubation is also of variable length depending on water temperature, and no hard and fast lines

[1] Eycleshymer, A. C. Amer. Nat. 1906. 40:134.
[2] Kneeland, S. Proc. Bost. Soc. Nat. Hist. 1857. 6:154.
[3] The temperatures were obtained by Paul A. Webb.

may be drawn. Conditions in a lake habitat are summarized by Eycleshymer as follows:[1]

> The time of egg-laying varies in different lakes, depending upon the time when the temperature of the water reaches a certain degree. In the larger, deeper lakes with bold shores this is much later than in those possessing wide shoals. Again, in individual lakes the time is dependent upon the same conditions. The eggs are first deposited in those localities, where the water is shallow and exposed for the greater part of the day to the sun. The period of egg-laying usually covers two or three weeks.

Eycleshymer collected eggs as early as May 3d and as late as June 5th, and these extremes probably marked the beginning and closing of the early and late seasons.

Smith, reporting on conditions in Lake Monona, Wis., writes:[2]

> A noticeable feature of the development as compared with other amphibians that I have studied, is the uniformity in the stage of development of embryos found in different nests in the same locality. On each of the following dates from four to seven nests were secured: June 22, 25, 29, July 5. On each date all the eggs were found so nearly in the same stage of development that only slight differences could be detected in eggs from different nests. This uniformity points to a very short spawning season—perhaps two or three days—in this locality; it would seem that all the eggs in a restricted area are laid at nearly the same time.

The writer has studied Necturus in northwestern Pennsylvania in streams tributary to the Allegheny and in general his observations on the length of the spawning season agree with those of Smith. As noted above, in 1925 the period covered 7 days. It has also been shown, however, that the water temperature was relatively high and that the streams were shallow. In deeper, colder waters there is every reason to believe the period of general deposition may start later in the season and that individuals may consume considerable time in depositing a single batch of eggs. On June 6, 1924, Paul A. Webb found a female in the process of egg-laying. Transferred from the warm waters of the stream to a tap water aquarium in the laboratory the process was resumed, but with a water temperature of from 62 to 66 degrees F. an entire day was consumed in depositing about a dozen eggs.

Eycleshymer found eggs in various stages of development in the same nest. Smith reported great uniformity in the stage of development of eggs in different nests in the same locality. The observations of both were probably accurately made. A sudden lower-

[1] Eycleshymer, A. C., Amer. Nat. 1906. 40:132.
[2] Smith, B. G. Biol. Bul. 1911. 20:193.

ing of water temperature might slow down or prevent for a short time the deposition of the eggs and account for the unequal development. There is another possibility though perhaps more remote. A single nest was found which contained 180 eggs. This number is considerably above the average and may represent the complements of two females.

Holbrook[1], who had little first-hand knowledge of Necturus, gives April and May as the spawning season and remarks that as many as 120 eggs have been counted in a single female. Eycleshymer[2] found 62 eggs in a single nest and a total of 117 eggs in three nests. Eycleshymer's figures are much below the average for the species and represent only one-third or one-half of the normal complements of full grown individuals.

THE NESTS OF NECTURUS

Smith, again reporting on conditions in Lake Monona, Wis., found nests in water from 3 to 5 feet deep and about 50 to 100 feet from shore where the bottom was strewn with loose flat stones. The larger stones frequently served as shelters for the nests. It is pointed out in this account that the water was so filled with minute algae that the bottom could not be seen and eggs were found by lifting stones to the surface. This is significant as will be shown later in the account of the brooding habit in Necturus. "The number of eggs present in a nest was determined in five cases as follows: 18, 61, 80, 84, 87. The average is 66."[3] The lower numbers certainly do not represent the full complement of a normal female. In three nests examined in Woodcock creek, Pennsylvania, the eggs numbered respectively 87, 96 and 140. The average of these is about 107. Paul Webb counted the eggs on several occasions and found that they numbered from 90 to 180 to a nest. If a female is disturbed during ovulation she may move to another spot and start over again. If she is robbed of her eggs she may continue to deposit in the same nest or move to another. I have found Cryptobranchus occupying a despoiled nest of Necturus. Embryos in nests in the immediate vicinity were in early stages of development so that the larvae could not have hatched and departed. Eycleshymer[4] found several nests in which the animals were distended with eggs and

[1] Holbrook, J. E. N. Amer. Herpetology, 2d ed. 1842. 5:113.
[2] Eycleshymer, A. C. Anat. Anz. 1904. 25:234.
[3] Smith, B. G. Biol. Bul. 1911. 20:191.
[4] Eycleshymer, A. C. Amer. Nat. 1906. 40:135.

inferred that the parent had devoured them because the nest had been disturbed. Smith[1] also discussed the nests of Necturus in a stream habitat but the account concerned the discovery of empty egg capsules in August. Eycleshymer[2] wrote of nests of Necturus in a lake habitat as follows:

> The objects beneath which the eggs are most frequently found are clean logs or boards which lie partially imbedded in the sand. The writer has also found them beneath pieces of tin, canvas, and even an old hat.
>
> The depth of the water in which these nests are found is variable. The writer has found nests covered by only 4 inches of water, again a nest was found beneath a board at a depth of 10 feet, but these are unusual conditions. The majority of nests are found at a depth of from 2 to 4 feet. The nests are often found in close proximity to one another; and it is not at all exceptional to find several nests on a single board frequently not more than a foot apart. In one instance ten nests were taken from a single board not more than ten feet long.

In northwestern Pennsylvania the writer has found nests in water varying in depth from a few inches to 2 feet. The "nests" themselves are shallow excavations beneath large flat stones partially imbedded in the stream bottom. Occasionally the stones lie almost on the surface but when imbedded there is usually a down stream entrance. They are commonly found near the rifts but not in the fastest water. The males are never found with the females on the spawning grounds. While the females are in the shallows with their eggs, the males occupy the deeper pools of quiet water. At least this is the situation in streams in northwestern Pennsylvania.

Necturus exercises less care in the selection of a retreat than Cryptobranchus but in some instances there was evidence that a considerable amount of material had been removed from the nest. In the writer's experience with Cryptobranchus it has been found that the male selects the nest site and prepares it for the female. With Necturus the female alone is found on the spawning grounds and is probably responsible for the selection of the site and its preparation.

The lower surface of the stone or board which forms the covering of the nest is the surface to which the eggs are attached. The eggs may be scattered over an area 12 inches or more in diameter or crowded together in a space only 6 or 8 inches square. The eggs are deposited one at a time and are attached by a circular, disk-like

[1] Smith, B. G. Biol. Bul. 1911. 20:193–94.
[2] Eycleshymer, A. C. Amer. Nat. 1906. 40:133–34.

expansion of the outer envelop, some 5 or 6 mm in diameter. There is a slight constriction below the attachment disk when the eggs hang in natural position buoyed up by the water but this lengthens to a slender stalk when the support to which the eggs are attached is lifted above the surface (plate 2).

THE BROODING HABIT

Smith[1] in part 1 of his paper on the embryology of Cryptobranchus remarks (p. 88): "The brooding habit seems to be lacking in Necturus." Again, in part 2 of the same report (p. 552) Smith says: "The absence of a brooding habit in Necturus is noteworthy." As pointed out in an earlier paragraph, Smith's studies of the nests of Necturus were carried on in Lake Monona, Wisconsin, where, "The presence of minute algae, etc., in the water made it so opaque that it was impossible to see the bottom; the eggs were obtained by wading in the water, feeling about with the feet for a large flat stone, then bringing it to the surface." Smith found only the empty egg capsules in a stream habitat in northwestern Pennsylvania and these were discovered in August, perhaps a month after the young had hatched. In a note on "The Breeding Habits of Salamanders and Their Bearing on Phylogeny," Dunn[2] writes, "Necturus lays nonpigmented eggs with large vitellus which are abandoned in the water."

In the writer's studies of Necturus a considerable number of nests have been found and in every instance the eggs were guarded by a female. These nests were in the clear, shallow streams of Crawford county, Pennsylvania, where it was possible to capture and examine the guardian parent. The females were found in nests with eggs in all stages of development and in nests in which the young were escaping from the egg capsules. The brooding habit is so well established that the female often makes little effort to escape when the sheltering rock or board is removed from the nest. With Cryptobranchus the male guards the nest and is usually found either among the eggs or under them. The female Necturus simply occupies the shallow retreat and is not in contact with the eggs except as her back may brush them as they hang from the support. She is not a particularly good guardian, however, for in one nest containing a large spent female a small Cryptobranchus 8½ inches long was found. Eggs had been deposited in the nest as indicated by the rings of jelly marking places of attachment on the under side

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[1] Smith, B. G. Jour. Morph. 1912. 23:88.
[2] Dunn, E. R. Copeia, no. 115. 1923. p. 27.

of the stone. In the business of stealing eggs Necturus itself is not guiltless. The writer has several times found them in the nests of Cryptobranchus where the guardian male was so busy with enemies of his own sex and species that he had little time to devote to the smaller invaders.

THE EGG AND ITS ENVELOPS

Surrounding the egg or embryo is a thin, tough and elastic membrane enclosing a jelly-like substance which may be slightly milky. A second thin layer, clear and transparent, incloses the first. The outer layer is much thicker, of jelly-like consistency and extremely elastic. The egg itself has a diameter of 5 to 6 mm, the inner envelop about 7 mm, the next outer layer about 8 mm. The short diameter of the outer envelop is about 11 mm and the long or vertical diameter (as the egg hangs in natural position) about 14 mm. Smith[1] gives details of the structure of the egg capsule in the following terms:

> There are three layers to the gelatinous envelop: (*a*) a comparatively thin but very dense inner layer, consisting of several lamellae; (*b*) a thicker median layer of moderate density, consisting of many lamellae; and (*c*) a very thick outer layer of homogeneous material, much less dense than either of the preceding. This outer layer is produced to form a stalk by which the capsule is attached to some solid support.

The writer has not observed the lamellae composing the two inner envelops. They are not at all evident in some early embryo material preserved in formalin, and the middle envelop as shown in Smith's figure (1912 p. 80, fig. 4) is much thicker and denser than in my specimens. Freshly laid eggs are yellow, the color usually light but varying in intensity in different lots.

ATTACHMENT OF THE EGGS

Concerning the deposition of the eggs Eycleshymer remarks:[2] "In just what manner the female deposits the eggs is . . . problematic. . . . In some way the female brings her body in such a position that the eggs are deposited on the sheltering object." Just how this was accomplished in one instance is shown in the figure here presented (plate 3). The female mentioned in an earlier paragraph, discovered in the act of laying her eggs, was transported to the laboratory where the process was continued. A large flat

[1] Smith, B. G. Jour. Morph. 1912. 23:79.
[2] Eycleshymer, A. C. Amer. Nat. 1906. 40:134.

stone supported on smaller stones provided a suitable " nest." The female turned herself upside down and supported her body with the toes of the front feet resting against the edge of the stone. This position she maintained for hours and deposited about a dozen eggs in the course of a day. The position assumed by this female is exactly that which might be expected in view of the disposition of the eggs; and it is no doubt the position taken by Eurycea bislineata, Pseudotriton ruber, Gyrinophilus danielsi and others which attach the eggs to the lower surface of a support in water.

SEGMENTATION AND GASTRULATION

The early cleavage stages in the egg of Necturus are discussed by Eycleshymer[1] in his paper on, " Bilateral Symmetry in the Egg of Necturus." In an earlier paper[2] the same writer gave an account of a series of puncture experiments on Necturus eggs and discussed briefly the early formation of the embryo. A few late embryo stages and an early larva are figured by Keibel[3]. Smith[4] gives drawings and photographs of the eggs and figures to show the late history of the blastophore and late cleavage stages.

LATE EMBRYONIC DEVELOPMENT

In 1925 the egg-laying season of Necturus in Woodcock creek, Crawford county, Pennsylvania, began on June 5th and continued without interruption through June 11th when the last fresh eggs were noticed. On June 21st a considerable number of embryos were transferred to the laboratory of Paul A. Webb for the study of late stages. On this date and thereafter at intervals of a few days specimens were preserved in formalin. About two hundred embryos were preserved on each of the dates given below:

	Incubated	*Period before hatching*
June 21st	16 days	22 days
June 25th	20 days	18 days
July 3d	28 days	10 days
July 13th	38 days	Hatching

Nests left undisturbed in the streams were also watched and on July 13th while hatching was well under way, several thousand

[1] Eycleshymer, A. C. Anat. Anz. 1904. 25:230.
[2] Eycleshymer, A. C. Anat. Anz. 1902. 21:341.
[3] Keibel, Franz. Die Kultur der Gegenwart, sec. 3, div. 4, v. 2, pt. 2. 1913. p. 346.
[4] Smith, B. G. Jour. Morph. 1912. 23:80, fig. 4, pl. 2, figs. 55–56; p. 480, figs. 107–08, pl. 10, figs. 268–79.

young were collected and transferred to open, shallow containers in the laboratory. These collections have furnished abundant materials for the study of late embryo and early larval development; and the results obtained have been checked against fresh material secured in the field.

June 21, 1925, 16 Days Old, 22 Days Before Hatching

The average length of the embryos at this stage is 14.8 mm. Eycleshymer[1], who watched the development of embryos through the hatching period, recorded the first indication of pigment in embryos 11 to 12 mm long. In specimens of that size the pigment appeared as small black dots well imbedded in the semitransparent connective tissue. In the specimens here considered there is a slight but definite development of chromatophores at the surface, enough pigment being present to give a light tinge of color to the dorsal surface of the head and trunk. The chromatophores are most abundant on the head and gradually thin out towards the tail (plate 4, figure 1). The position of the eyes is indicated by a slight development of tissue.

The buds of the gills are elongate, set in an oblique row and in some instances provided with one or two short branches. The buds of the fore legs are low rounded protuberances; those of the hind legs are not as well developed but perfectly evident in most specimens. They appear as rounded humps at the base of the tail. There is distinct evidence of metameric development on either side of the mid-line of the back. The yolk hangs as a deep broad keel so that the depth of the body is equal to about one-third of the length. The tail where it extends beyond the trunk comprises about one-fifth of the total length.

June 25, 1925, 20 Days Old, 18 Days Before Hatching

The average length of the embryo at this stage is 16.9 mm. The depth is 4.6 mm. The chromatophores are much more numerous at the surface and are distributed not only over the head and trunk but extend laterally over the upper surface of the yolk, distally almost to the tip of the tail and on the sides of the head to the base of the gills. In some specimens the eyes are not only indicated by development of tissue but by a slight concentration of pigment. The gills are longer and slimmer and provided with two or three short filaments. The buds of the fore legs have elongated considerably

[1] Eycleshymer, A. C. Anat. Anz. 1914. 46:7.

and are directed backward and upward. The buds of the hind legs show little advance. There is a marked growth of the tail and tail keels and the back is more strongly arched than in the earlier stage. Tissue concentrated in the region of the vent indicates rapid development of the posterior end of the intestinal canal. The tail now comprises almost one-fourth of the total length but the bulk of the body is still in the yolk (plate 4, figure 2).

July 3, 1925, 28 Days Old, 10 Days Before Hatching

Specimens at this age average 19.2 mm with the tail 5.7 mm. The pigmentation is more intense and extends over the upper sides of the yolk and to the extremity of the tail. On the head the pigment extends well over the snout and slightly below the lower margin of the eyes. In this stage there is no evidence of segregation of pigment to form the bands which are so conspicuous in older individuals. The eyes are so developed that the iris and pupil may be distinguished. The superficial chromatophores, which marked the position of the eyes in the stage preceding this, have for the most part disappeared and the iris is colored by more deeply imbedded pigment. The gills bear short filaments in two rows. On the under side of the head there is a transverse groove which starts below the eyes, follows the contour of the snout and marks the position of the developing mouth. A slight but definite swelling in the throat region is followed by a second transverse groove, the gular fold. The nostrils are evident just below the eyes on the ventral surface of the head. There is little advance in development of leg buds. In some individuals, however, the buds of the fore legs are more elongate and slightly constricted at the middle. The yolk mass is still large but not as prominent because of the lengthening of head and tail (plate 4, figure 3).

LARVAL GROWTH AND DEVELOPMENT

July 13, 1925, Larvae at Hatching, Length of Incubation Period, 38 Days

Plate 5, figure 1

The average length of twenty larvae picked at random from a lot collected in the field and preserved on the day of hatching is 22.5 mm. This does not accord with the measurements of Smith[1] who obtained an average length of 18 mm. The discrepancy may possibly be explained: If the eggs are removed from the place of attach-

[1] Smith, B. G. Biol. Bul. 1911. 20:195.

ment, the envelops are more or less ruptured and permit, in many cases, the premature escape of the embryo. We have guarded against this possible source of error by collecting the larvae in the field at the time of hatching.

The measurements tabulated below indicate a variation in length of 4 mm in the different individuals.

21.0 mm	22.0 mm	22.5 mm	23.0 mm
21.5	22.0	22.5	23.5
21.5	22.0	22.5	24.0
21.5	22.0	23.0	24.0
21.5	22.0	23.0	25.0

The extremes of 21 and 25 mm probably mark the limits of variation in length at hatching.

The lot from which the measured specimens were taken furnished some two hundred additional individuals having a length of 22 mm.

At hatching the gills are provided with two rows of filaments, the terminal ones considerably elongated and flattened. The toes of the front feet are evident as four short, pointed branches. The toes of the hind feet are scarcely differentiated but the hind legs themselves show some advancement in their greater length. The eyes are well pigmented and apparently functional at hatching. The mouth, lips, nostrils and gular fold are well formed. The yolk is still conspicuous and colors the sides and ventral region between the fore and hind legs. The tail shows marked development and comprises about four-elevenths of the total length. The dorsal keel proper originates at a point above the insertion of the hind legs and is continuous with a slightly raised ridge which runs along the mid-dorsal line of the back to a point above the fore legs.

Color Pattern

A very narrow light line follows the sharp edge of the dorsal ridge. A strongly pigmented median dorsal band originates on the snout a little in front of the eyes and continues along the back and on the tail where it fades out towards the tip. On the head it maintains a width about equal to the distance between the eyes but just behind the gills it narrows abruptly. The dark dorsal band is bordered on each side by a somewhat narrower yellow band which in this stage is free from dark pigment. These light bands originate opposite the base of the third gills and continue along the upper part of the sides and the basal third of the tail where they are usually lost in the general pigmentation of the upper tail fin. On the head the dark median area is bordered on either side by a short light bar which originates in front of the gills and passes to

the upper margin of the eye. In some individuals it narrows above the eye and continues to the snout.

Below the lateral light bands are the conspicuous dark stripes of the sides, extending from the gills to the tip of the tail. They are continued on the head in bands that curve downward in front of the gills, pass through the eyes and run together on the snout. Below the dark bands the pigment gradually fades out as it spreads over the yolk distended abdomen, the upper surface of the limbs and the gill branches. In some individuals there are a number of small, rounded light spots quite regularly spaced throughout the length of the lateral dark band.

Besides those preserved at the time of collection, July 13th, a considerable number were placed in formalin solution on each of the following dates:

	No. of days after eggs were laid	*No. of days after hatching*
July 16th	41	3
July 18th	43	5
July 21st	46	8
July 23d	48	10
July 27th	52	14
Aug. 3d	59	21
Aug. 7th	63	25
Aug. 20th	76	38
Aug. 23d	79	41
Aug. 27th	83	45
Aug. 30th	86	48

July 16, 1925, 41 Days Old, 3 Days After Hatching

The measurements of twenty-five specimens preserved three days after hatching are tabulated below:

24.0 mm	24.0 mm	25.0 mm	25.0 mm	25.5 mm
24.0	24.5	25.0	25.0	25.5
24.0	25.0	25.0	25.0	26.0
24.0	25.0	25.0	25.0	26.0
24.0	25.0	25.0	25.0	26.5

The average is 24.9 mm with extremes of 24 and 26.5 mm, a variation of 2.5 mm. There is a noticeable advance in development of the gills and toes, a slight reduction of the yolk and a considerable increase in the intensity of the pigmentation (plate 5, figure 2). The lateral light bands of the body stand out in strong contrast against the dark longitudinal bands and are now almost continuous with the light bars of the head which pass above the eyes. On the tail the light bands are still confined to the basal third. The ventral keel of the tail remains unpigmented but a few scattered chromatophores fleck the sides of the abdomen. The change in the gills is brought about through the lengthening and flattening of the fila-

ments, the terminal pair in particular being longer than the others, somewhat constricted at the base and pointed distally.

July 18, 1925, 43 Days Old, 5 Days After Hatching

Measurements of twenty specimens are given:

25.0 mm	25.5 mm	26.0 mm	26.0 mm
25.0	25.5	26.0	26.0
25.0	26.0	26.0	26.5
25.5	26.0	26.0	26.5
25.5	26.0	26.0	27.0

The average length is 25.8 mm with the range from 25 to 27 mm. On this date it was possible to select from the general collection about two hundred individuals each 25 mm long.

During this period of 2 days the slight increase in length of gill filaments and the more intense pigmentation are about the only features worthy of note.

July 21, 1925, 46 Days Old, 8 Days After Hatching

Twenty specimens give the following measurements:

25.0 mm	26.0 mm	26.5 mm	27.0 mm
25.0	26.0	27.0	27.0
25.0	26.0	27.0	27.0
25.5	26.0	27.0	27.0
26.0	26.5	27.0	27.0

Here again the variation is from 25 to 27 mm, but the average of 26.3 mm shows a gain in length of .5 mm in the three-day period.

July 23, 1925, 48 Days Old, 10 Days After Hatching

Measurements of a considerable number of individuals on this date show scarcely a gain in length but the gills at this time are provided with filaments which are longer, slimmer and more flattened. The toes of the hind feet show as separate members, the fourth shortest. The dark longitudinal bands are very dark in life and stand out in strong contrast against the lateral light lines. The latter are continuous on the trunk and head and extend in some instances one-half the length of the tail (plate 6, figure 1).

July 27, 1925, 52 Days Old, 14 Days After Hatching

Two weeks after hatching, twenty larvae measured:

26.5 mm	27.0 mm	27.0 mm	27.5 mm
26.5	27.0	27.5	28.0
26.5	27.0	27.5	28.0
26.5	27.0	27.5	28.0
27.0	27.0	27.5	28.0

The average is 27.2 mm, with extremes of 26.5 and 28 mm, a gain of 4.7 mm in 2 weeks.

August 3, 1925, 59 Days Old, 21 Days After Hatching

The twenty larvae measured:

27.0 mm	27.5 mm	28.0 mm	28.0 mm
27.0	27.5	28.0	28.5
27.0	28.0	28.0	28.5
27.0	28.0	28.0	29.0
27.0	28.0	28.0	29.0

The average is 27.8 mm, with variation from 27 to 29 mm. Another lot of fifteen individuals hatched July 15–18th and measured 21 days later, averaged only 26.6 mm. It is evident that there is some variation not only among individuals hatched from the same batch of eggs but between different lots or series of specimens.

The larval color pattern is almost completely established at this age and the following description from life will indicate, to some degree, the character of its development. Under the microscope the median dorsal band is grayish brown and extends from a point just back of the nostrils to the tail, where it involves only the dorsal fin. To the unaided eye the color appears very dark, almost black. The dorsal band is bordered on either side by the narrower light line, yellowish white, with irregular edges. These light lines originate above the nostrils, pass just above the eyes and continue along the sides of the body and on the tail, one-third or one-half its length. The light lines are usually interrupted or broken just above the gills. Below the light lines the dark bands of the sides pass along the sides of the snout, through the eyes and continue to the tip of the tail. The color is grayish brown, like the dorsal stripe, but darker. The sides below the dark lateral bands are distinctly greenish gray, flecked with yellow in small, rounded spots. The color of the lower sides fades into the distinctly yellow belly.

The sides of the head below the eyes are yellowish flecked with gray; the throat is dirty white except where colored by the heart, and the lips are slightly pigmented. The ventral tail fin is light gray. The gills are beautifully developed, two rows of flattened filaments to each branch and all of a delicate pink color. The fore legs are provided with four well-formed toes; the hind legs are held out at a right angle to the body but have the toes only slightly developed. The yolk occupies the abdominal region but there is little distention of the wall.

August 7, 1925, 63 Days Old, 25 Days After Hatching

The average length at this age is 29.5 mm. The extremes are 29 and 30 mm for the series measured (plate 6, figure 2).

At about this age the larval development of the gill filaments reaches its highest point. Thereafter there is a gradual shortening of the filaments and they take on a more regular arrangement. The full development of the larval gills is discussed under a separate head in a later paragraph.

August 20, 1925, 76 Days Old, 38 Days after Hatching

By August 20th an average length of 33 mm had been attained. The lateral light stripes are continuous over the gills and extend on the tail almost to the tip. Both dorsal and lateral dark stripes have, in some instances, a few small, round yellow spots. Below the lateral bands the sides of the abdomen are strongly spotted. The extreme upper margin of the dorsal tail fin is largely free from pigment and a few chromatophores speck the ventral fin. The toes of all feet are well formed. There is a marked shortening in the gill filaments.

August 23, 1925, 79 Days Old, 41 Days After Hatching

For a considerable period after August 20th specimens were preserved at intervals during which an average increase in length of 1 mm had been attained. On August 23d the length was 34 mm. The following description from life will indicate the changes in the color pattern: The median dorsal band is sharply defined and dark but there is an increase in the number of small, rounded spots which are free from pigment. This band extends to the tip of the tail and colors the dorsal fin except at the extreme upper margin. The lateral light bands coalesce on the snout in front and continue along the body to the tip of the tail where they are more or less broken by intrusions of pigment from the mid-dorsal band. The lateral dark bands meet on the snout, continue through the eyes and along the trunk to the tip of the tail. These bands are greenish gray and darker than the dorsal stripe. The sides below the lateral bands are mottled with yellowish white spots. The belly, particularly the posterior half, is still colored by the yolk. The chin has a considerable number of chromatophores present and a few are scattered over the belly. The legs and feet are strong and well pigmented above.

August 27, 1925, 83 Days Old, 45 Days After Hatching

On this date some two hundred individuals were selected which had an average length of 35 mm. There are no striking changes in the color pattern.

August 30, 1925, 86 Days Old, 48 Days After Hatching

Length 36 mm. The yolk mass is confined to the posterior half of the abdomen and is much reduced. The gill filaments also show marked reduction.

The increase in length of larvae during the eight day period following hatching is greater than that attained during the next 17 days. Thereafter the growth is slower, coincident perhaps with the reduction of the yolk.

DEVELOPMENT AND REDUCTION OF THE LARVAL GILLS

Plate 11, figures 1–6

A series of drawings has been prepared to illustrate some of the changes that take place in the development of the larval gills. Figure 1 represents the gills at the time of hatching. The filaments are short, pointed, almost straight and disposed in two rows. The terminal pair are broader than the others and considerably flattened. A few chromatophores are present at the base. Development is rapid and the condition in a larva 3 days after hatching is shown in figure 2. The gills are larger and the filaments longer and quite slender. The condition 10 days after hatching is shown in figure 3. There is a notable increase in the size and length of the filaments. The terminal filaments consist of a pair of broad, blunt pointed, flattened plates and the others show some advance. The gills reach their highest development about 25 days after hatching and thereafter there is a gradual shortening of the filaments (figure 4). Figure 5 shows the condition 38 days after hatching. The filaments have been reduced and present a comb-like appearance but the gill itself is stouter and wider in proportion to its length than in preceding stages. During the next 10 days there is little change in the appearance except in the increased pigmentation (figure 6).

The rapid growth of the filaments and their subsequent reduction are phases of development through which the larvae of true salamanders pass during growth and transformation. The facts are significant and should receive some attention when relationships of Necturus are considered. If the length of the gills is compared to the length of the head it will be found that the maximum size is attained at about 3 weeks and again at sexual maturity. During the intervening years the growth is exceedingly slow.

YEARLY GROWTH AND DEVELOPMENT

With the material at hand, it is possible for the first time to give definite measurements to show the annual growth of Necturus maculosus to sexual maturity. The data tabulated below give the results of measurements of specimens taken at one locality on French creek, Crawford county, Pennsylvania, between August 20 and 30, 1925. For the past three years eggs of Necturus at this locality have hatched between July 13th and July 25th. The measurements therefore represent a little more than the annual increments of growth, that is, specimens regarded as a year old are actually about 13 months old.

Necturus, First Year

Plate 7, figure 1

49.0 mm	52.5 mm	55.5 mm	60.0 mm
50.5	52.5	56.5	60.0
51.0	53.0	57.0	60.0
51.0	53.0	57.5	60.0
51.0	54.0	57.5	60.5
51.0	54.0	58.0	60.5
51.5	54.0	58.5	63.0
51.5	54.5	59.0	63.0
52.0	55.0	59.0	63.0
52.5	55.0	59.5	63.0
52.5	55.5	59.5	64.0

The average length of these forty-four specimens is 56.1 mm. Thirty-nine of the lot varied in length only 11.5 mm, or from 49 mm to 60.5 mm. The specimens falling within these limits may safely be regarded as yearlings. The five remaining specimens are 63 and 64 mm in length. Judged by length only, these five specimens might be regarded either as well advanced yearlings or stunted two-year-old specimens. In general, however, the two-year-old specimens are decidedly more robust and as these specimens are slender, they are probably individuals hatched early in the season and fortunate in their food supply. The extreme variation in length in specimens one year old is 15 mm.

At the age of one year the larval pattern is still well developed but the median dorsal band instead of being dark gray or almost black is definitely yellowish brown. In the majority of specimens the dorsal band ends abruptly at the origin of the dorsal tail keel; in others it continues to color the fin to the extremity of the tail. The lateral light bands are a deep dull yellow. They are prominent on the head back of the eyes and in some instances extend to the nostrils in front. They persist along the trunk and in many specimens unite at the anterior end of the dorsal tail fin and continue to the tip. Where this occurs the dorsal fin is lacking in dark pigment (plate 9, figures 1 and 3). This distribution of pigment is not

uncommon in specimens recently hatched and is also found in those 2, 3 and 4 years old. It is pertinent here to call attention to the figures given by Smith[1] to show the tails of larval Necturi from northwestern Pennsylvania and Detroit river. Writing of the color pattern in a larva from Pennsylvania he says:

This specimen differs from the western larvae in that the dorsolateral stripes unite in the median line at the base of the tail, to be continued as a single stripe along the dorsal edge of the tail. Since this peculiarity is present in all the fourteen larvae that I have examined from the eastern habitat, it would appear to be a constant difference between the eastern and western forms.

As pointed out above, when the dorsal band ends at the base of the tail, the keel above is without dark pigment and takes its color from the united lateral light bands; when the dorsal band continues to the tip, the dorsal keel is dark (plate 9, figures 2 and 4). Age, size of specimen or locality seem to have nothing to do with this variation in pigment arrangement.

The dark lateral bands in year old specimens continue as in younger larvae, from the snout through the eyes to the tip of the tail. The lower sides may be definitely spotted or almost uniform in color. This series is marked by great uniformity in the light ventral color. In the majority of specimens the margins of the lips are dusky and there are intrusions of pigment on the sides of the head below the eyes. A few specimens have chromatophores scattered over the entire venter. The gills and their filaments are very short when compared with those of larvae 3 to 6 weeks old. In the latter the gills may be over half as long as the head; in the year old specimens, less than one-third.

Necturus, Second Year

Plate 7, figure 2; plate 9, figures 3 and 4

Specimens to establish the limits of size of two-year-old Necturi were secured with difficulty. In 10 days' collecting only seventeen specimens were discovered but it is believed that with this series the average size can be determined with considerable accuracy. The measurements follow:

70.0 mm	81.0 mm	90.0 mm
70.0	83.5	92.0
74.0	84.0	92.0
78.0	85.0	92.0
80.0	85.0	95.0
81.0	86.0	

As might be expected, the variation in size is greater than in the series of one-year-old specimens. The individuals which the writer

[1] Smith, B. G. Biol. Bul. 1911. 20:197, figs. 4–5.

has regarded as falling within the two-year-old limit vary from 70 to 95 mm. The average length is 83.4 mm. The shortest member of this group is only 4 mm longer than the longest one-year-old specimen but length has not been the only factor considered in determining age. Differences in body proportions are strikingly evident when the series of both ages are placed side by side.

In seven specimens the median dorsal band persists as a rather narrow stripe, distinct and bordered by dull yellow. In the other specimens this band is wider, dull yellow mottled with dark brown, the dark predominating. The yellow bands bordering the median stripe are dulled by scattered chromatophores of darker pigment and this is particularly true on the head. In a few instances they remain well marked from the snout to the tip of the tail. The dark lateral bands are constant in all specimens of the series and in four individuals they are continued on the tail to color the dorsal fin. In three specimens rounded dark spots are scattered over the dorsum. The venter in the majority of the specimens is very lightly pigmented and in no instances are there rounded dark spots present. The gills and filaments continue to be proportionally shorter than in larvae 3 to 6 weeks old.

Necturus, Third Year

Plate 7, figure 3

97.0 mm	107.0 mm	111.0 mm	116.5 mm	126.0 mm
97.0	108.5	114.0	118.0	128.0
101.0	109.0	114.0	120.0	128.0
103.0	109.5	115.0	120.0	
105.0	110.0	115.0	124.0	
105.0	110.0	116.5	125.0	

In this series of twenty-seven specimens the average length is 113 mm. The extremes of 97 and 128 mm show a variation in length of 31 mm. The average gain in length over members of the two-year-old class is 29.6 mm.

The median dorsal band persists as a narrow uninterrupted stripe in only five specimens. These are among the smallest of the series and range from 97 to 110 mm in length. In a single specimen 124 mm long the dorsum is entirely dark, its color impinging on the lateral dark areas without a separating light stripe. In the balance of the specimens the dorsal area is dusky brown with a broken and irregular median band indistinctly developed. The longitudinal light stripes which in young larvae are disposed more on the sides of the trunk, gradually assume a dorsal position. This is due to the change in shape of the body rather than to any definite shift in pigment. The head in the majority of the specimens is a dull yellowish brown although in a few specimens in which the dorsal band is distinct,

the median area of the head is dark. The dark lateral bands still persist although somewhat broken and mottled. They are usually distinct on the sides of the head and pass through the eyes. The lower sides are strongly spotted. In four specimens the venter is white; in two, gray spotted with black; in the others, rather uniformly, lightly pigmented.

Necturus, Fourth Year

Plate 7, figure 4

130.0 mm	140.0 mm	144.0 mm	149.0 mm	161.0 mm
130.0	140.0	145.0	152.0	161.5
131.0	140.0	146.0	157.0	164.0
135.0	142.0	147.0	159.0	164.0
137.0	142.0	147.0	160.0	165.0
139.0	143.0	148.0	160.0	165.0
				167.0

The range in length is from 130 to 167 mm in the series studied and the variation is 37 mm. The average length of the thirty-one specimens is 148.7 mm. This is an average gain in length of 35.7 mm in 1 year.

In the four-year-old specimens the color above is usually chocolate brown with a few scattered, rounded, bluish black spots. In one specimen 145 mm long the dark lateral band persists along the trunk and there is an indication of the dark dorsal stripe. In four, remnants of the light stripe remain but are very dull in color and broken. The dark sides are mottled with bluish black spots and irregular areas free from dark pigment. The dark lateral bands are most in evidence on the tail and on the sides of the head. The majority of the specimens have attained a color pattern essentially like that of the sexually mature. In this series three have white or very light bellies; fourteen are uniform dusky grayish brown and the balance have a few rounded dark spots on a dusky ground. The gills are still comparatively short.

Necturus, Fifth Year

Plate 7, figure 5

169.0 mm	175.0 mm	183.0 mm	192.0 mm	202.0 mm
169.0	176.0	184.0	192.0	203.0
170.0	176.0	185.0	195.0	203.0
170.0	176.0	186.0	195.0	205.0
170.0	177.0	186.0	196.0	206.0
170.0	178.0	186.0	196.0	208.0
170.0	178.0	186.0	196.0	210.0
171.0	178.0	188.0	198.0	210.0
171.0	179.0	188.5	198.0	210.0
172.0	179.0	190.0	200.0	210.0
174.0	180.0	190.0	200.0	
174.0	180.0	190.0	200.0	
174.0	181.0	190.0	201.0	
175.0	182.0	190.0	202.0	

The sixty-six specimens in this series have an average length of 187 mm. They vary from 169 to 210 mm or 41 mm. The average gain in length over specimens 4 years old is 38.3 mm.

In individuals of this size the variation in color is essentially that of the sexually mature, except that very rarely the dark lateral stripe of the side is retained. In one specimen 182 mm long the band is conspicuous on the head and tail and quite well preserved on the sides of the trunk.

In determining the age of specimens which have a length over 200 mm, consideration must be given to the general conformation for many specimens of this length are probably in their sixth year.

Necturus, Sixth Year

Plate 7, figure 6

While it is altogether probable that many individuals only 200 mm long are in their sixth year, a study of the considerable series of specimens from Pennsylvania indicates that where water conditions are good and food is abundant, a minimum length of about 230 mm may be attained. The measurements given in this report are based on collections made in one locality where there is every indication that the species is successful. Numbers alone do not give an accurate measure of the success of a species for an area may be overpopulated with consequent increase in competition, reduction of available food and retarded growth. A species may be regarded as successful where it maintains itself in full vigor, copes with its enemies and does not exhaust its food supply. An interesting comparative study of development might be made if it were possible to secure a sufficient number of specimens from more barren waters.

Individuals may reach sexual maturity at a length of 200 mm. Since mating takes place in the fall and ovulation in the spring following, the males in any series of the same age must mature the sexual elements several months before the female. Some dissections of females taken in the fall and winter show that the eggs have attained a diameter of about 3 mm. The mature egg is about 6 mm in diameter.

THE ADULTS

Size

Plate 8

Several hundred specimens from various parts of Pennsylvania and New York have been available for study. In addition a few individuals from North Carolina and Canada have been examined. The largest specimen in the entire series measured 432 mm (17

inches) in length and it is probable that this size is rarely exceeded. The writer believes with Eycleshymer[1] that there is little foundation for the statements of authors, (Jordan,[2] Hay,[3] Pratt,[4] *et al.*), that the species attains a length of 24 inches or more. In fact the average length is nearer 12 inches although specimens 15 inches long are not uncommon.

In a male 302 mm long the body proportions are as follows: head length, 51 mm, measured from end of snout to the base of the first (dorsal) gills; the width at the widest point, 38 mm; tail from posterior end of vent, 34 mm; tail shorter than normal and the tip seems to have been regenerated; width of the trunk, 38 mm; legs short and of equal length, 35 mm; the third toe of each foot longest. In a female 325 mm long the corresponding measurements are: head length, 54 mm; width, 38 mm; tail, 100 mm. In any considerable series the females average a little larger than the males.

Form

The body is stout, somewhat depressed and with a distinct median dorsal groove. The head is broad and flat behind the eyes and gradually narrows to the truncated snout. Labial and gular folds are well developed. The costal furrows number fifteen if axial and inguinal are counted. In proportion to its size, the eyes are extremely small. The gills are about one-third as long as the head or, if filaments are included, about one-half as long. The filaments are very slender, flattened and brushlike in appearance. The blood supply to the filaments is under control and when the flow is restricted the filaments lose their bright red color and shrink almost half their length. The mouth is large and extends on the sides of the head to a point just behind the eyes. The nostrils are on the front of the snout near the lateral angles. The tail is broad and strongly compressed and widest a little beyond the middle of its length.

Color

While there is considerable variation in the color of adult specimens, greater uniformity is found than in Cryptobranchus which is so often associated with Necturus where the ranges overlap. Variation in Necturus is expressed not only in the general ground color but in the arrangement, number and conspicuousness of the dark

[1] Eycleshymer, A. C. Amer. Nat. 1906. 40:123.
[2] Jordan, D. S. A Manual of the Vertebrate Animals, 10th ed., 1910. p. 175.
[3] Hay, O. P. 17th Rep't State Geol. Ind. 1892. p. 419.
[4] Pratt, H. S. A Manual of Land and Fresh Water Vertebrate Animals of the U. S. 1923. p. 147.

spots. The color of a large majority of specimens is a deep rust brown—small flecks over blue-black. Where the brown is absent the black pigment strikes through to form rounded spots one-eighth to one-fourth of an inch in diameter. The spots may be almost or quite absent in a few specimens or developed only on one side of the body. A few individuals in any collection of considerable size will have the back marked with a double series of regularly disposed spots. These specimens are likely to have a lateral series which is reminiscent of the lateral stripe of the young. The upper surfaces of the legs are usually spotted, rust brown over blue-black. Often there is a reddish or orange tinge of color about the margins of the tail, particularly noticeable in the smaller specimens. In some individuals the only remnant of the dark lateral stripe is found in the dark bar which passes through the eye. This may be short and indistinct or well developed. In other specimens the sides of the tail also retain a dark central area. The venter in adults is usually rather uniformly pigmented but lighter than the back. A considerable number have the belly marked with a light median stripe, broad in some and reduced to a narrow line in others. A few have dark spots on a dull ground.

Sexual Differences

The sexes are, in general, alike in form and color. There are, however, some slight differences in body proportions. Measurements of a considerable number of individuals indicate that the head of the male is on the average a little longer than that of the female. In a pair, each 275 mm long, the head of the male is 48 mm long while that of the female is 45 mm. The male of another pair of equal length (280 mm) has a head length of 51 mm while that of the female is only 49 mm. A male 285 mm long has a head length of 52 mm which exactly equals that of a female 312 mm long. Head measurements are of doubtful value, however, in the determination of sex when preserved specimens are used and are unnecessary when it is possible to examine the vent.

The vent in the male is a longitudinal slit, obliquely wrinkled at the margin, bounded posteriorly by a transverse crescentic groove and provided with a pair of nipplelike papillae, one on each side just in front of the groove. The male vent is larger than that of the female and in the breeding season is surrounded by a swollen and inflamed ridge. This ridge marks externally the limits of the large cloacal gland lying below the surface. The vent is capable of being everted and in such a condition presents to the surface many

fine tubules and the two strongly diverted papillae. The slightest abrasion while the vent is swollen and inflamed causes it to bleed freely. In the female the vent is a simple slit, smooth externally and usually surrounded by a narrow light-colored area.

It is quite possible to distinguish the sex in four-year-old individuals. The vent in a male 142 mm long has the characteristic crescentic groove and the paired papillae are evident as short backward directed lobes.

Glands of the Skin

That mudpuppies are "slimy" to the touch is evident to anyone who has handled living specimens. A thin layer of slime or mucous is at all times present on the surface of the skin and probably serves the mudpuppy in the protection it gives against Saprolegnia; for Necturus as well as fish are subject to attack by these destructive organisms[1].

A recent paper by Dawson[2] includes an account of the dermal glands of Necturus. Two distinct types are recognized: (1) those which produce mucous, and (2) those filled with a dense granular secretion. Occasionally mixed glands are found. The glands of Necturus are not aggregated in special areas and little specialization has taken place except in the cloaca. The mucous glands are generally distributed over the surface of the body except on the soles of the feet and in the gular fold and are more abundant on the ventral surface than the granular glands. The latter are largest and most abundant on the dorsal surface of the body and in areas along the dorsal and ventral edges of the tail. The product of the mucous glands is a clear, slimy fluid which is poured out over the surface of the skin when the animal is slightly irritated. Granular secretion is discharged under strong stimulation.

Dawson[3] also gives an interesting account of the pigmentation and changes in coloration. Some of his findings, briefly summarized, are as follows: Pigment may be present in ordinary epidermal cells. Special pigment-bearing cells of the epidermis, apparently of two types (pyramidal and highly branched) may be contraction and expansion phases of one kind of cell. The epidermal chromatophores are not derived from those of the dermis and specialized pigment cells may perhaps be produced by metamorphosis of ordinary epidermal cells. Melanophores and xanthophores were found in the

[1] Morse, Max. Proc. Ohio State Acad. Sci. 1904. 4:107.
[2] Dawson, A. B. Jour. Morph. 1920. 34:526.
[3] Dawson, A. B. Jour. Morph. 1920. 34:487–589, pls. 1–6, 36 figs.

dermis, the former usually arranged in two layers, the latter with the melanophores of the outer layer. Changes in coloration are brought about by expansion and contraction of the dermal melanophores. The melanophores are expanded in bright light and contracted in darkness and at low temperatures. Melanophores appear to be of fixed form, within which pigment granules migrate in "contraction" and "expansion."

Individual specimens may have a ground color that differs markedly from the average. But when a considerable number of specimens are confined in a tank and subject to definite control of light, the ground color is remarkably uniform. As before mentioned, in bright light the chromatophores are expanded and the general color is dark. In the dark the chromatophores contract and the color may vary from light to dark tan. A single large specimen from Cayuga Lake, N. Y., exhibited albinistic tendencies. The color in life was a uniform dull yellow without darker markings. The writer has not found all black specimens but a single larva in a series reared from the egg was so dark that the lateral stripes were scarcely distinguishable.

Garnier[1] described specimens from the Maitland river which were characterized in part by their smaller size, uniform black color, sooty abdomen and white gular fold. For this variety the name "Latastei" was proposed. But the name has gone into the synonymy of Necturus maculosus and the specimens have been regarded simply as aberrantly colored individuals. The writer has examined one from Pointe au Baril, Georgian Bay, collected in the summer of 1925 by Leonard Giovannoli of Lexington, Ky. This specimen is small, 92 mm long, dark bluish-brown above and marked with two faint lines of small light dashes which run from a point back of the eyes to the base of the tail. The belly is light. There is a striking resemblance in color to specimens of Necturus punctatus of the same size. The Pointe au Baril specimen would be conspicuous in any series of Necturus maculosus and it is significant that it was collected in the general region which supplied Garnier's specimens.

It is to be expected, perhaps, that near the periphery of the range of a widely distributed species, individuals will show more than the usual variation from normal. In this connection attention may be directed to the recently described dwarf form of N. maculosus which is found in North Carolina[2].

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[1] Garnier, J. G. Proc. Can. Inst. 1888. 3d ser. 5:218.
[2] Brimley, C. S. Jour. Elisha Mitchell Sci. Soc. 1924. 40:166.

Abnormalities

In the entire series of several thousand young larvae only three abnormal individuals were found. Two of these were "spiral tailed monsters," adopting the term applied by Smith to similarly distorted individuals of Cryptobranchus. The third specimen was of unusual color, the light bands being obscured by uniform distribution of dark pigment.

The figures (plate 10) show the character of the abnormal specimens better than any written description. In size they compared favorably with normal larvae of the same age, being equally endowed with yolk. In open competition they would not long survive. Their bodies being permanently twisted they were obliged to swim in circles and as often as not upside down. They responded to stimuli as promptly as the normal individuals but the movements were without definite direction. In moving from one part of the container to another, the path formed a series of closely overlapping spirals.

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EXPLANATIONS OF PLATES

Plate 1

Woodcock Creek near Saegertown, Pennsylvania. Typical stream habitat of *Necturus maculosus* (Rafinesque). Photographed June 23, 1924, by S. C. Bishop.

Plate I

Plate 2

A "nest" of eggs of Necturus maculosus (Rafinesque). The stone with eggs attached, removed from the water and tipped on its edge. Photographed June 23, 1924, by S. C. Bishop. About one-half natural size.

Plate 2

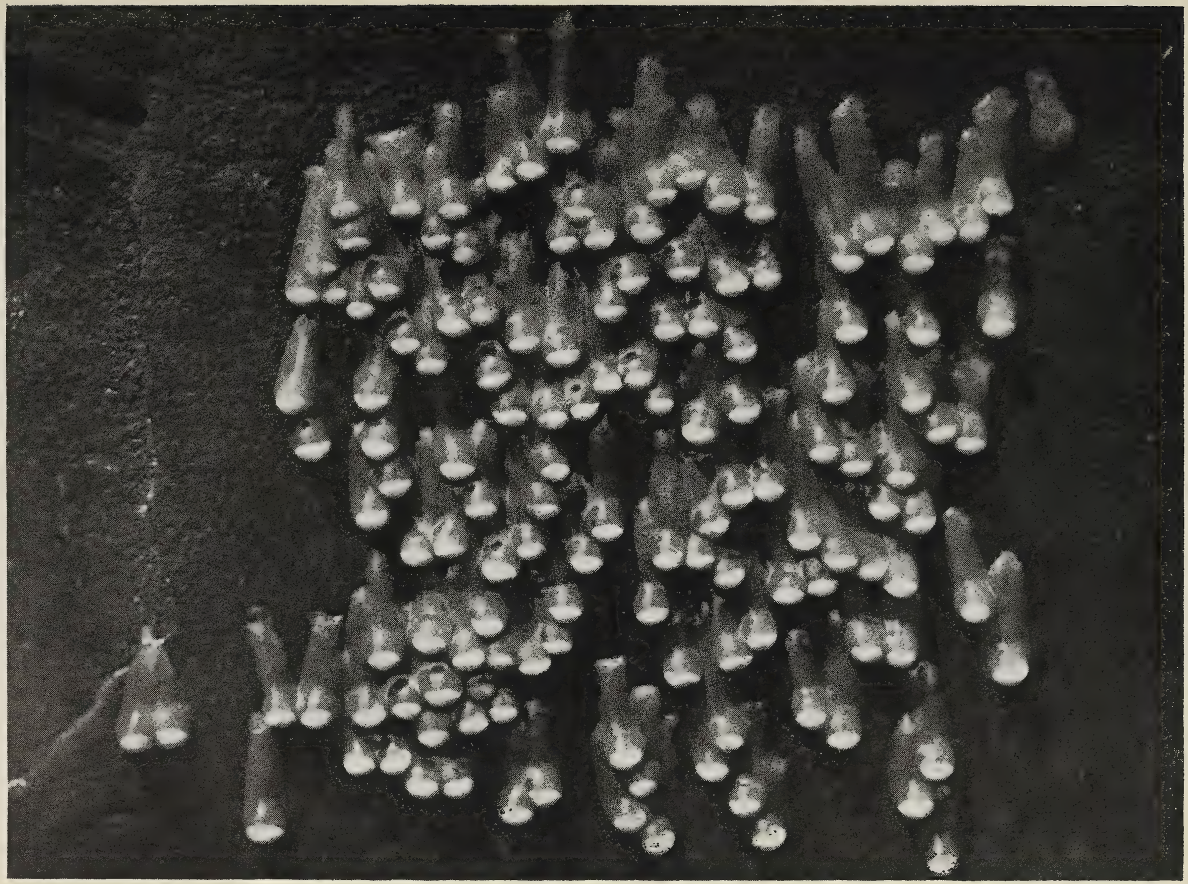

Plate 3

Necturus maculosus (Rafinesque)

A female in the position assumed during the egg-laying process. Drawn by Walter J. Schoonmaker.

Plate 3

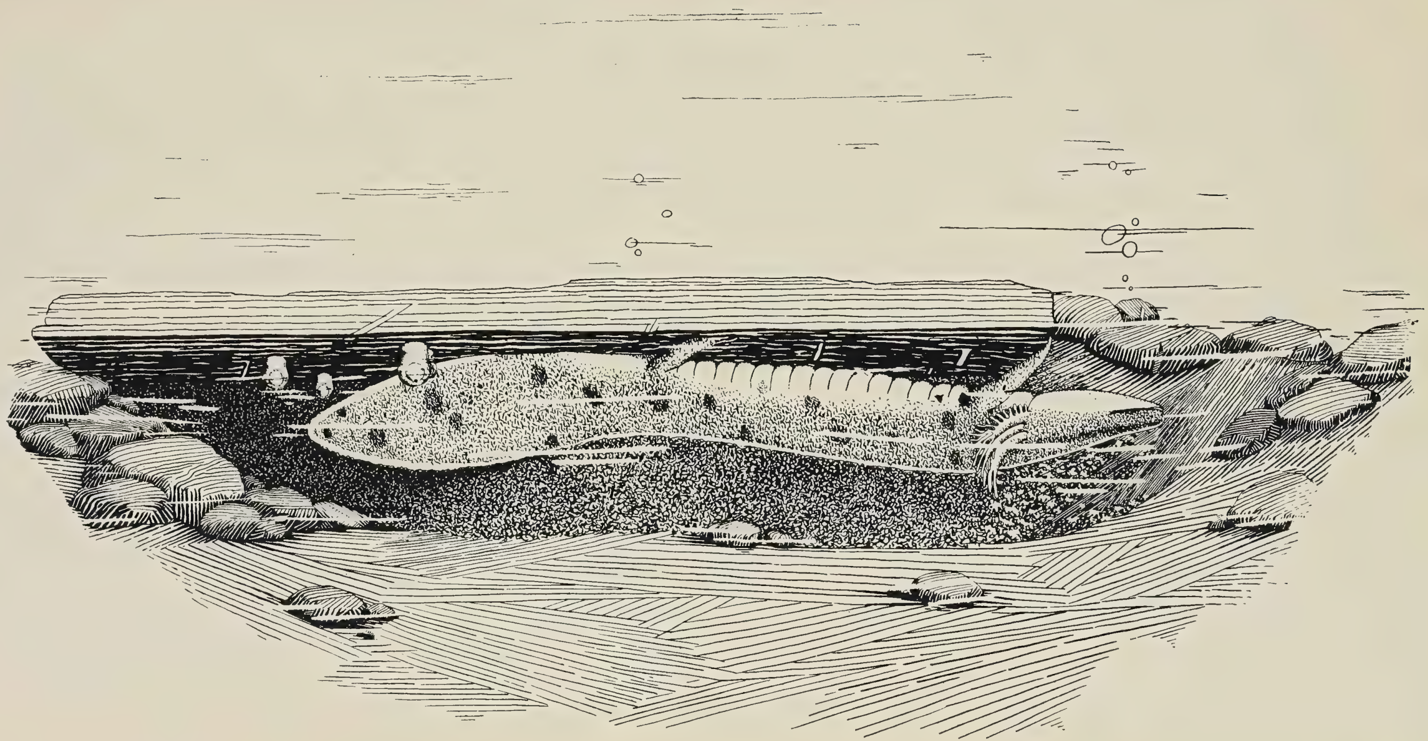

Plate 4

45

Necturus maculosus (Rafinesque)

Figure 1 Embryos 16 days old, June 21, 1925. Formalin specimens, twice enlarged.

Figure 2 Embryos 20 days old, June 25, 1925. Formalin specimens, twice enlarged.

Figure 3 Embryos 28 days old, July 3, 1925. Formalin specimens, twice enlarged. Photographed by E. J. Stein.

Plate 4

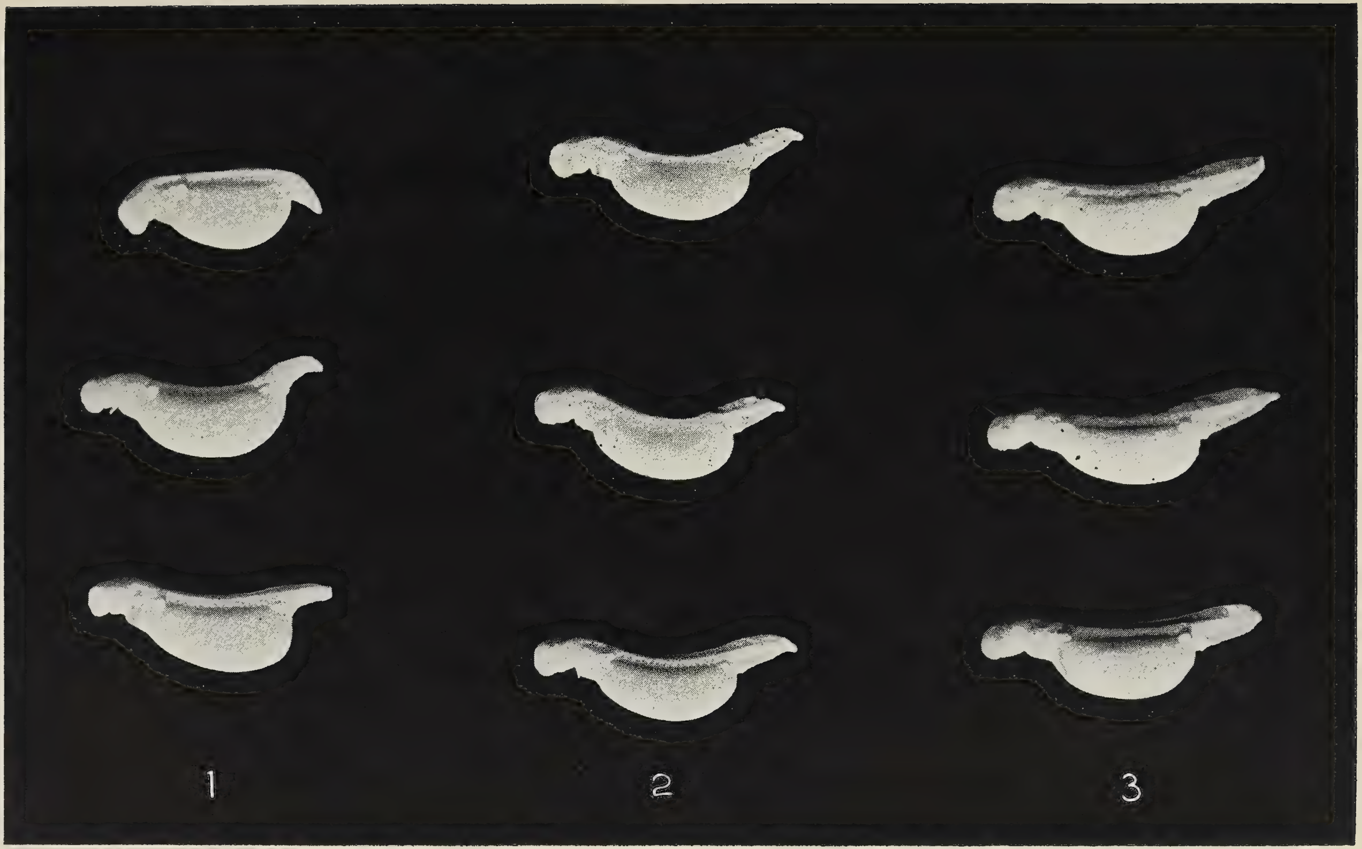

Plate 5

Necturus maculosus (Rafinesque)

Figure 1 Larvae at hatching, July 13, 1925. Formalin specimens, twice enlarged.

Figure 2 Larvae 3 days after hatching, July 16, 1925. Formalin specimens, twice enlarged. Photographed by E. J. Stein.

Plate 5

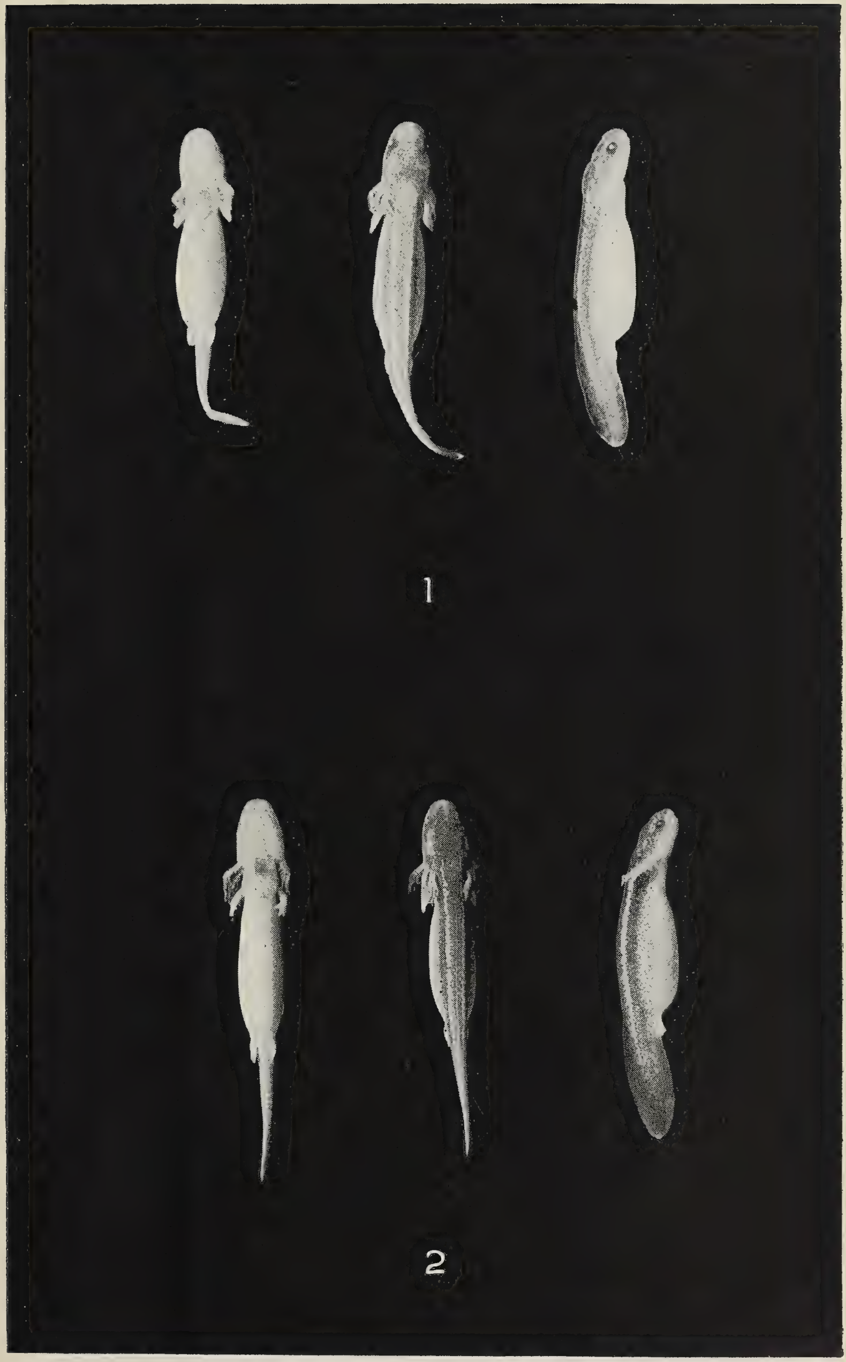

Plate 6

Necturus maculosus (Rafinesque)

Figure 1 Larvae 10 days after hatching, July 23, 1925. Formalin specimens, twice enlarged.

Figure 2 Larvae 25 days after hatching, August 7, 1925. Formalin specimens, twice enlarged. Photographed by E. J. Stein.

Plate 6

Plate 7

Necturus maculosus (Rafinesque)

Mudpuppies 1 to 6 years old. Living specimens, natural size, photographed under water. The lateral light bands so distinctive of the larvae are usually almost entirely lost during the third year. The dark bands of the sides often persist in older specimens. The living specimens available for photographing did not, in every instance, represent the average length of the species for the year. Thus the figure of the four-year-old specimen represents an individual of the maximum size for the age. Figures 1 and 2 photographed by E. J. Stein; others in the series by S. C. Bishop.

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Plate 8

Necturus maculosus (Rafinesque)

A mature specimen of moderate size photographed in Woodcock creek. The white scars on the surface of the skin mark the places of attachment of small, flat, parasitic worms. About twenty exposures were made before the camera caught the gills fully expanded. Photographed June 23, 1924, by S. C. Bishop. Slightly less than natural size.

Plate 8

Plate 9

Necturus maculosus (Rafinesque)

Figure 1 Tail of a one-year-old specimen enlarged to show the color pattern. The dark dorsal band stops at the base of the tail and the dorsal keel takes its color from the united light bands.

Figure 2 In this specimen the dark dorsal band continues to the tip of the tail.

Figure 3 A two-year-old specimen about natural size. Dorsal keel without dark pigment.

Figure 4 The dark dorsal band continued to the tip of the tail. Formalin specimens.

Plate 9

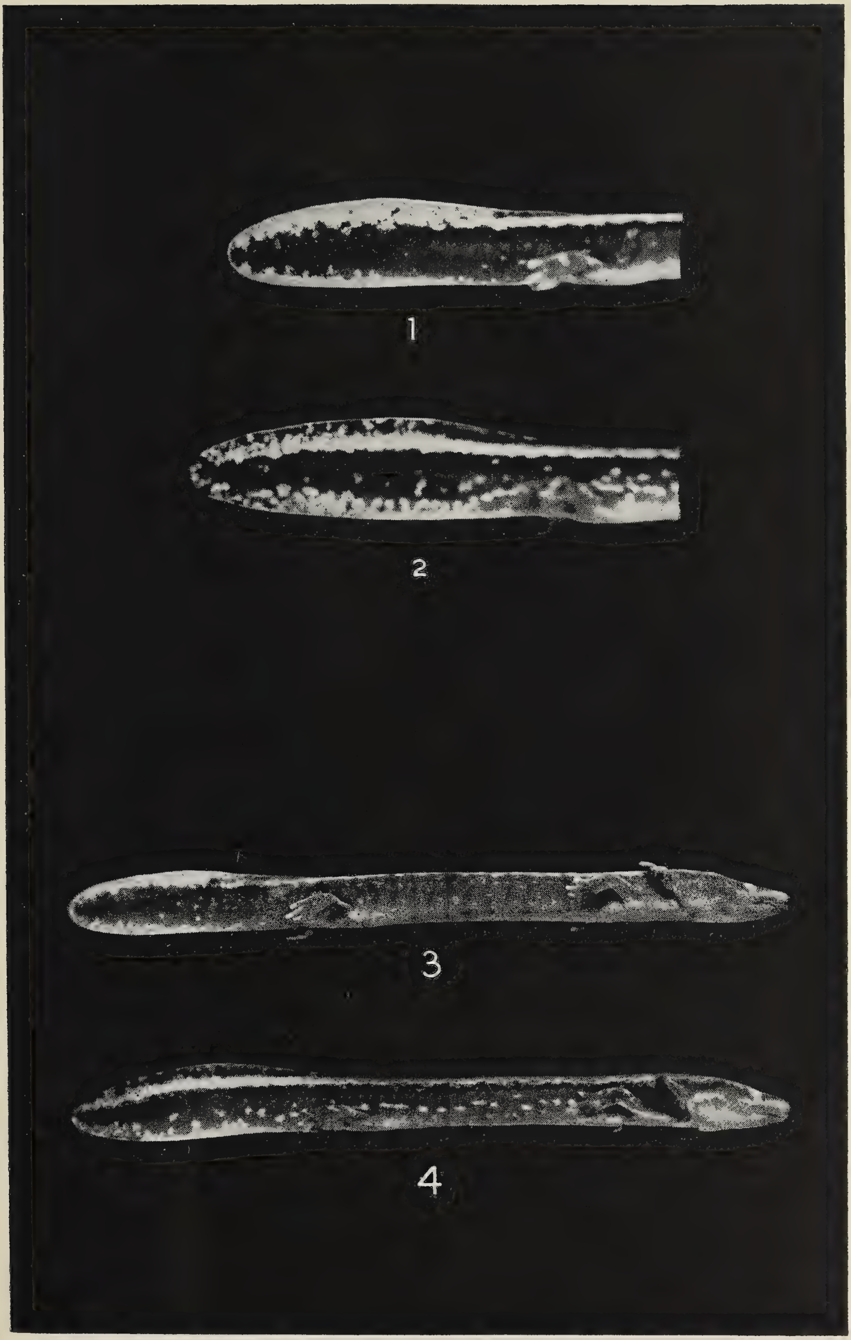

Plate 10

Necturus maculosus (Rafinesque)

Abnormal larvae. The body is spirally twisted and forces the larva to swim in circles. Photographed from life by S. C. Bishop and enlarged about 3 times.

Plate 10

Plate 11

The Development and Reduction of the Larval Gills

Figure 1 The gills at hatching, July 13, 1925. The filaments are short, pointed and regularly disposed.

Figure 2 The gills 3 days after hatching, July 16, 1925. The filaments show considerable development. Curiously enough every other one has about doubled in length.

Figure 3 Ten days after hatching, July 23, 1925. Marked increase in size and length of the terminal filaments is shown and some indication of the increase in chromatophores.

Figure 4 Twenty-five days after hatching, August 7, 1925. The larval gills at the height of their development.

Figure 5 Thirty-eight days after hatching, August 20, 1925. The filaments have again shortened and taken on a comblike appearance.

Figure 6 Forty-eight days after hatching, August 30, 1925. Pigmentation greatly increased. The gill itself is heavier and thicker in proportion to the length of the filaments. Drawn by Walter J. Schoonmaker.

Plate 11

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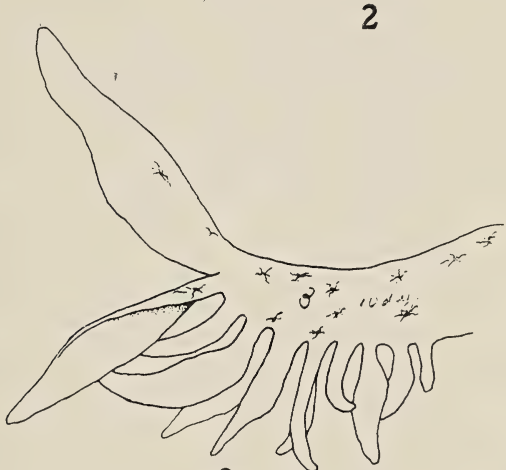

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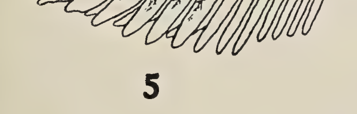

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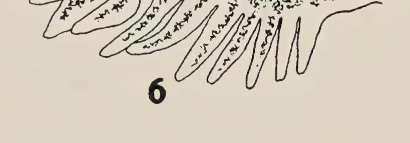

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New York State Museum Bulletin

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New York State Museum

GEOLOGY OF THE LAKE BONAPARTE QUADRANGLE

BY

C. H. SMYTH jr

AND

A. F. BUDDINGTON

ALBANY

THE UNIVERSITY OF THE STATE OF NEW YORK

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GEOLOGY OF THE LAKE BONAPARTE QUADRANGLE

BY

C. H. SMYTH jr and A. F. BUDDINGTON

INTRODUCTION

The Lake Bonaparte quadrangle, though including such well-known mineral localities as Diana, Natural Bridge and Pitcairn, does not appear to have been mentioned in geological literature until 1892, when Van Hise (1892, 388–99) published a brief statement of the results of a visit to the region made by him in company with the late Professor George H. Williams of Johns Hopkins University.

In 1892, the senior author, Professor C. H. Smyth jr, undertook the investigation of the western Adirondack region, starting in the vicinity of Gouverneur, St Lawrence county. Two years earlier, Professor J. F. Kemp of Columbia University had begun a similar study of the eastern Adirondacks and a little later Professor H. P. Cushing of Western Reserve University joined in the work, which in subsequent years was carried on with frequent comparisons and interchange of views.

The earlier work was all of a reconnaissance nature, and considerable areas were gone over rapidly, in an effort to determine the broader geological features of the region. Adequate base maps were lacking, and the modern methods of study and interpretation of Precambrian rocks were imperfectly developed. In consequence, many things that now seem obvious, at that time gave much trouble. Still, the greater problems of Adirondack geology were solved, at least to the extent of a first approximation.

In extending the work from the Gouverneur district, it was decided to examine during the summer of 1894 a region including the Lake Bonaparte quadrangle. This purpose was mentioned, inci-

dentally, in a letter to Professor G. H. Williams, who, in his reply, suggested joining in the early part of the study. Later, an afternoon and evening were spent at the writer's home in a discussion of plans, into which Professor Williams entered with all his customary enthusiasm; but this proved to be his last geological talk as, next day, he was stricken with the illness that led soon to his untimely death.

Some of the results of the field work in 1894 were published during the following year (Smyth, 1895), and another brief visit in 1897 gave additional information (Smyth, 1899), but it was clear that the region was of such complexity that no satisfactory investigation of the geology could be carried out without a good base map. This did not become available until the spring of 1916, when Doctor Buddington, having been appointed to a proctor fellowship in Princeton University, was able to devote his time to a detailed study of the region. He spent the entire summer in the field, and during the winter, in association with the writer, prepared the present report in the geological laboratory of the university.

Although in a general way the main conclusions of the earlier work are confirmed, many serious mistakes and crudities have been brought to light, while much that was entirely overlooked before is here discussed in detail. It need hardly be said, however, that the present report is far from being exhaustive, much less, final. Indeed, it has been found necessary to condense in high degree nearly all the topics treated, in order to keep within reasonable limits.

The question of gneissic structure has been treated at some length because of its particular importance in the area; but other topics, such as the theoretical aspects of magmatic differentiation, injection gneisses, contact metamorphism etc., have been greatly compressed or barely mentioned. This is due, in part, to the limitations of space and, in part, to the necessity of awaiting further data from surrounding areas.

The senior author feels that he can not close this introduction without testifying to the fact that whatever value the report may have is due to the ability, enthusiasm and unflagging industry of Doctor Buddington.

PHYSIOGRAPHY

The Lake Bonaparte quadrangle lies within, and close to the western border of, the Adirondack region.

The drainage is, in general, northwestward into the St Lawrence, and the altitudes range from 600 feet in the northwest, to somewhat over 1400 feet in the southeast corner of the area.

The topography is hilly, with quite moderate relief, becoming more rugged on the eastern border. Broad, flat, fairly well settled valleys, floored with Pleistocene sand, make a striking topographic feature. These valleys are developed on the more soluble and easily eroded limestone bands. It is also in the limestones that the basins of the several lakes and ponds of the area are excavated. The mixed gneiss formation of the northeast part of the area forms a characteristic rough topography, with frequent cliff faces; while the syenite to the southeast gives, for the most part, rounded hills with flowing contours. The fine-grained granites form a comparatively flat-topped table-land, covered mostly with a thick growth of underbrush.

The direction of drainage has been controlled almost entirely by the strike and foliation of the different formations, and their relative resistance.

Only a small portion of the area is cleared land, and this is, in general, thinly settled, dairying being the chief industry. The region has been almost completely lumbered, and is characterized throughout by a second growth forest full of débris and slash, with several burnt areas.

GENERAL GEOLOGY

The rocks of this quadrangle belong to formations of three different ages: the Precambrian, Cambrian and Pleistocene. The Precambrian rocks constitute the bed-rock geology almost exclusively. The Cambrian deposits are represented by several scattered patches of low dipping, white sandstone with, rarely, a basal conglomerate or pebble bed — mere disjointed remnants of a once continuous blanket, which formerly covered the northwest portion of the district. The Pleistocene deposits comprise a thin, discontinuous veneer of glacial drift over the surface of the uplands, and of stratified sands in the valleys.

The region may be considered, in a broad way, as comprising three bands of different lithological characteristics.

Southeastern Band

The entire southeastern band, constituting the southeastern half of the district, is formed by a great mass of heterogeneous, foliated, banded syenitic rock, occupying over a hundred square miles. It varies in a very broad sense, going from the northwest to the southeast, from a basic augite syenite to a biotite granite. Three bands, in each of which there is a wide variation in composition, but in each of which one rock is dominant, may be distinguished. These are an augite syenite band, a hornblende syenite band, and a hornblende-biotite granosyenite band.

Central Band

The central band, about 4 miles wide, comprises a belt of crystalline limestones, Grenville gneiss, and mixed rocks, intruded, for the most part parallel to the foliation, by sheets and bosses of gabbro, syenite and granite, the latter usually a coarse porphyritic type. The mixed rocks consist of Grenville gneiss in advanced stages of disintegration by granitic pegmatite and, to a less extent, by syenite and granite. The Grenville portions comprise biotite, cordierite, garnet, graphitic, pyroxene, pyritous, sillimanite and quartzose gneisses. Spinel has been noted in contact metamorphic zones. Cordierite gneisses have not been hitherto described from the Grenville of the Adirondacks.

South of Lake Bonaparte the gneisses are intruded by a batholith of fine grained granite.

Northwestern Band

The northwestern band is a rock complex consisting of three types: (1) An elongated granite batholith, which is almost completely surrounded by a belt of garnet-biotite gneiss, arched up by the granite, and consisting of Grenville material, injected and disintegrated by pegmatite. The granite possesses a foliation, which conforms in strike and dip to that of the adjacent invaded rock and is enveloped by a contact metamorphic shell or reaction zone of garnet rock about 100 feet thick, with included beds of amphibolite and pyroxene gneiss. (2) An area of quartz-biotite gneiss of granitic character, forming the northwest corner, and intruded by a boss of porphyritic granite. (3) A narrow tongue of crystalline limestone and white quartzite beds overlapping from the Gouverneur quadrangle.

POTSDAM SANDSTONE

Only a few small outliers of the Potsdam sandstone have been left by erosion within the area covered by this sheet. These represent merely disconnected relics of a continuous sheet which formerly covered most, if not all, of the northern half of the quadrangle. The remnants which remain are in limestone valleys of Precambrian age, which lie beneath the present general level of erosion. Several other patches, too small to map, were found in the field. There is one just north of Natural Bridge, another about a mile and a half north of the same place, and a small patch in the swamp north of Bullhead pond. The Potsdam everywhere rests with an angular unconformity on the underlying limestones and quartzites.

The largest area, a little over a mile southwest of Lake Bonaparte, forms a unique topographic feature. The Cambrian sandstones here rest on an old Precambrian valley floor, excavated in limestone, and bordered by steep cliffs about 100 feet high on either side. The top of the sandstone surface is considerably lower than the tops of the bordering cliffs. The agents of erosion have cut through the sandstone around its borders, adjoining the cliffs, and reached the underlying limestone. The result has been to leave a large, flat-topped, mesa-like feature, separated by a fosse from the higher cliffs surrounding it. The white sandstones, which stand out conspicuously when the rays of the sun are reflected from them, are in striking contrast to the somber-colored Precambrian rocks around them. The little pond on the east side also lies in a chasm of Precambrian age which has, again, been brought to light by the erosion of its previous sandstone filling.

The Potsdam sandstone is dominantly a white sugary sandstone, partially or completely cemented with quartz, which has been deposited as a secondary enlargement of the quartz grains. Little rusty spots are common on weathered surfaces. Crossbedding is common, and ripple marks and raindrop prints are occasionally seen.

The Potsdam formation southeast of Kinsman school consists of a reddish quartzite conglomerate, or breccia, and red sandstones, in addition to outcrops of white sandstone. In one outcrop the red standstone, containing pockets of conglomerate, is overlain by the white. The base of the white sandstone appears to be at an elevation of about 730 feet. The fragments in the conglomerates are of a white, angular, crystalline quartzite, similar to the hard, jointed, Grenville quartzites interbedded with the limestones underlying the Potsdam at this locality.

PRECAMBRIAN METAMORPHIC SEDIMENTARY ROCKS

Limestones

The most characteristic rocks of the Grenville series are the crystalline limestones. Within this district, these form a considerable portion of the central belt, and occur intermingled with the other rocks. The tip end of another belt, lying northwest of this, occurs around Sylvia lake, but the beds here are associated with quartzitic layers and probably form a different horizon. In addition, thin beds of limestone occur intercalated within the pyroxene gneisses northeast of Harrisville and in the garnet gneiss series around the California batholith.

The limestones are invariably coarse crystalline rocks, usually white or light gray in color. They have been so thoroughly recrystallized as to constitute marbles. Bands with disseminated phlogopite, pyroxene and graphite are common. The phlogopite and pyroxene may be evenly distributed or they may be segregated into nodular forms. In both conditions the pyroxene is often altered to serpentine, giving rise to ophicalcite and serpentine marbles. Tremolite is locally abundant, and scapolite is constantly associated with contact metamorphic zones.

In general, the limestones are so massive that it is difficult to ascertain the strike and dip and, owing to the differential flowage which these rocks have undergone, little significance can be attached to such observations when obtained. The limestone, under the great load and stresses to which it has been subjected, has acted like a plastic rock, like dough, or like a viscous fluid, flowing around fragments of more brittle rocks, cutting across intercalated gneiss beds like dikes of igneous rocks, and being squeezed aside by the numerous intruding bosses of igneous rock. In thus acting as a mobile mass, it has preserved from crushing many of the dikes and intercalated gneisses inclosed within it, and, owing to its facility for recrystallizing, shows no effects of crushing. Even the dikes which are displaced often show massive textures in displaced fragments.

Only locally are large areas of the limestones free from intrusive bosses and dikes of the various igneous rocks. One such area is that northeast of Pitcairn, and another is east and south of Lake Bonaparte. There is a general absence, however, of pegmatite veins in the limestone.

Locally, near the borders of the limestone belts, thin beds of rusty gneiss are intercalated within the limestones. These may be

thoroughly injected with pegmatite veins, whereas the limestones remain unaffected.

Beds which show by their mineral character that they are of igneous metamorphic origin, although no igneous rock may be seen in the immediate vicinity, are common. Such are the bed of scapolite-wollastonite-pyrrhotite rock north of the road east of Natural Bridge, where the Indian river crosses it, and the mass of coarse tremolite rock, 1 mile south of Lake Bonaparte station, in which the individual crystals of the aggregate average several inches in length.

Limestones with Intercalated Siliceous Beds

Alternating beds of limestone and white crystalline quartzite, both thick-bedded and thin-bedded, outcrop around Sylvia lake and in the vicinity of Kinsman school. Intercalated beds of white diopside rock and tremolitic limestones are also common.

Especial interest attaches to these rocks from an economic viewpoint in that the belt around Sylvia lake is the same which, along its northeastern extension, contains the talc veins of the Gouverneur district.

The rocks in the Kinsman school band are similar to those of Sylvia lake, and locally carry talc deposits and contain many serpentinized strata and tremolitic beds susceptible of alteration to talc. The beds here also are cut by many sheets of porphyritic granite gneiss. Near Deerlick creek the beds are dolomitic, and are quarried to burn to magnesian lime. The rock between the quarry and the road consists of narrow bands of marble between sills of red syenite augen-gneiss and occasional sheets of porphyritic granite. Narrow beds of garnet-biotite gneiss are also intercalated in these beds, and finer grained siliceous beds with considerable diopside, which weather gray, are also present. The serpentine bands are usually associated with the siliceous, quartzitic and tremolitic layers which vary from 3 to 15 feet in thickness, and are particularly prominent northeast of Kinsman school. Just south of the school, a thick bed of milky white quartzite, which can be traced southeast for about a mile, is completely brecciated, crumpled and folded. Some of the beds of this series correspond to those described by Martin (1916), from the Canton quadrangle, as quartz mesh limestones.

MIXED ROCKS

The mixed rocks have been formed by the more or less intimate intermingling and reaction of igneous material with the Grenville schists and limestones. The rocks as a whole are treated under the heading of foliation, and only a brief description of the Grenville portion alone will be given here.

The area in the northeast, or the Edwards area, includes at the core some fine-grained granite, tainted in variable degrees with relics of Grenville gneiss and alternating with bands and blocks of granitized Grenville gneiss. These rocks are surrounded by a wide border of biotite-garnet gneiss of granitic composition, the product of the injection and recrystallization of Grenville rock by pegmatite and granitic juices. The rock of this border zone is similar to that mapped as biotite-garnet gneiss in the northwest part of the quadrangle. At the core, similar gneiss is associated with rusty weathering pyritous gneisses and sillimanitic gneiss, in addition to the intruded granite. All the gneisses are cut by numerous dikes of medium-grained or, occasionally, porphyritic granite.

The belt of gneiss running through Pitcairn, and the biotite-garnet gneiss belts, consist of Grenville formations in the last stages of disintegration by the multitude of pegmatite veins injecting them. Much of the gneiss in the Pitcairn belt is the biotite-garnet gneiss, but some of it is sillimanitic.

The gneiss around the border of the Clark pond batholith is severely fractured and the blocks are forced apart by a network of intruding granite dikes. These blocks, however, for the most part still retain their strike to such an extent that their general trend can be carried across from one inclusion to another. Farther from the main batholith, the gneiss on its southern border is injected by syenite, and in its northern portion is pegmatized.

Pyroxene Gneisses

The pyroxene gneisses constitute a band about ½ mile wide, running northeast from Harrisville, and dipping beneath the overlying limestones. A narrow band of similar gneiss, included in the granosyenite, is found near North Croghan. Its location is along the line of strike of the pyroxene gneisses, and it may well represent a portion of them caught in the intruding magma and preserved.

Pyroxene gneisses, of different character, occur in the vicinity of Lake Bonaparte; these often carry hypersthene, associated with hornblende, garnet and other minerals.

The gneisses northeast of Harrisville are, in reality, mixed rocks, being formed of pyroxene gneiss injected and intruded by thin films, sheets, and sills of granite along the northern portion, and by somewhat thicker sheets and sills of syenite along the southern portion. The granite is not present in inclusions of gneiss caught in the syenite, is less mashed than the syenite, is similar in character to that of the Clark pond batholith, and hence is presumably younger than the syenite, although no granite dikes in the syenite were found.

Numerous beds of limestone are interstratified with the gneisses along the northern portion, and give conclusive evidence of the sedimentary origin of the latter.

The pyroxene gneisses themselves are typically medium-grained, black to greenish gray, granular rocks, injected either by granite or syenite, and frequently weathering with a ribbed or pitted surface, due to solution of calcite. In thin section they are seen to be composed of pale green pyroxene, quartz, orthoclase and other feldspars, in varying proportions. The feldspars are often altered to sericitic aggregates. Calcite and titanite are the common accessory minerals.

Some beds which are very interesting, mineralogically, occur within this belt. Such are beds of white, vitreous, diopside rock, varying up to 100 feet in thickness, which outcrop at several places along the southern border. They are reticulated with milky-white veins of quartz and diopside. About 1 mile east of Pitcairn there is a 20-foot bed of diopside-tremolite rock, with accessory plagioclase and scapolite. It is pyritic, and weathers rusty. Another bed, on the edge of the hill about 1¼ miles west of Harrisville, consists of scapolite and dark green pyroxene. Rarely, an amphibolite bed is present.

The black pyroxene gneisses, northeast of Lake Bonaparte, appear like typical amphibolite, and are often indistinguishable in the field from the gabbro. They are usually more highly foliated, however, and in thin section are seen to carry hypersthene, a mineral absent from the gabbro and common to the basic gneisses of sedimentary origin. They are thoroughly broken up, intruded, injected (plate 22, upper figure), or disintegrated by syenite, and are probably of contact metamorphic origin, derived from the action of the syenite upon the calcareous beds of this district. In thin section the gneiss is found to consist of hypersthene with a faint reddish

tint, monoclinic pyroxene, microperthite, biotite and plagioclase in varying amounts, with accessory garnet, apatite and zircon.

The small island at the southwest end of Lake Bonaparte presents an amazing succession of banded basic gneisses, about 800 feet thick. Limestones occur at the water's edge, and are succeeded by alternating bands of monoclinic pyroxene, hornblende, scapolite, and hypersthene gneisses. The rock resembles somewhat the banded appearance of the gabbro at Geers Corners. The monoclinic pyroxene gneisses present a thin-bedded appearance with alternating darker and lighter bands of proxene and meionite, respectively. Locally the rock is deeply weathered along narrow bands, indicating the former presence of calcite. It is composed almost exclusively of monoclinic pyroxene, faintly pleochroic from reddish brown to greenish gray, and scapolite ($Me_{85}Ma_{15}$). Feldspathic veins with a trace of phlogopite and scapolite are also present. The hypersthene gneiss is dark gray, with a purplish hue, and weathers rusty. It consists of hypersthene and plagioclase (Ab_1An_1) with accessory biotite. The hornblende gneiss, or true amphibolite, is greenish black gneiss and composed almost exclusively of deep green hornblende and andesine (Ab_3An_2). Although no igneous rock was noted in the immediate vicinity, these gneisses are doubtless of igneous metamorphic origin, derived from calcareous beds.

Biotite-Cordierite-Garnet-Quartz-Sillimanite Gneisses

These minerals are written in their alphabetical order because they are, apparently, of so nearly equal abundance; and it is so difficult to distinguish between what is Grenville in origin and what is injected material, that no attempt was made to determine precisely their relative importance. The rocks belong with the rusty gneisses which are so common throughout the Grenville formations of the Adirondacks, the pyrite which they almost invariably contain oxidizing and giving to the weathered surface a yellowish or reddish brown color. The gneisses around the Clark pond batholith are more compact and massive, and less injected by well-individualized pegmatite veins than the other masses, and present a more typical bedded appearance. These, therefore, present the best opportunity for study, since the others are so shredded and disintegrated by granite and pegmatite that they afford, only now and then, a well-defined bed.

Among the rocks around the granite batholith, particularly between it and Lake Bonaparte, the following types have been recognized,

the minerals being named in their order of abundance: garnet-cordierite gneiss, garnet-biotite-cordierite gneiss, garnet-biotite-sillimanite gneiss, garnet-sillimanite gneiss, cordierite-garnet-sillimanite gneiss, garnet-biotite-sillimanite-cordierite gneiss, quartz-sillimanite gneiss and sillimanite-biotite gneiss.

Accessory minerals are pyrite, which is invariably present, locally titanite, and (in gneiss close to the granite) occasionally spinel and hypersthene. Monoclinic pyroxene and hornblende are very rare except in the amphibolite beds themselves. White quartzitic beds, quite thin and resembling quartz veins, are locally common, as well as greenish gray quartzites carrying a little pyroxene. Occasionally a garnet rock is present in thin beds. Graphite is distributed through some of the beds in the Pitcairn and Edwards belts, especially in the more quartzose phases.

Biotite. The biotite is commonly pleochroic from a pale yellowish or greenish brown to rich deep brown. It occurs in plates, whose length is several times their width, usually oriented parallel to the foliation. For the most part it occurs between the other minerals.

Cordierite. In a review of the literature no previous mention has been found of this mineral occuring in the Grenville gneisses within the Adirondacks. It has probably escaped detection hitherto because it is usually altered to a micaceous aggregate for which, unless a fragment can be found in the process of alteration, it is difficult to assign an origin. Very fresh grains of the mineral were first found in a coarse granular aggregate of quartz and cordierite, constituting a recrystallized inclusion of Grenville in the granite on the border of the Clark pond batholith (plate 12, upper figure). It was afterwards found in various stages of alteration, but usually completely altered, in many of the other rusty gneiss areas.

The cordierite, when fresh, appears on the weathered rock surface as a dull black mineral with a bituminous luster. On a fresh fracture surface, it is vitreous and of dark smoky color. When altered, it takes on the usual green color of pinite. In thin sections cordierite shows elongated forms with embayed borders oriented parallel to the foliation. The fresh sections are colorless, with abundant minute inclusions of a highly refracting mineral surrounded by yellow pleochroic halos. Some of these grains are definitely zircons. Often the cordierite shows a penetration twinning, resembling that of plagioclase, and it is always altered along numerous cracks to a fibrous micaceous mineral. With increasing alteration the mineral becomes wholly a micaceous aggregate, but with the network of irregular cracks still preserved. It occurs not only in

the granitic injection gneisses, but also in the syenitic injection gneiss, and rarely in the rock of the syenite sheets themselves.

Garnet. Garnet is locally very abundant in many of the pegmatite veins, and may form narrow bands of rich garnet rock. The color varies from dark red to a very delicate amethystine tone. The grains are usually minute or small, but may reach half an inch in diameter. In thin section they are nearly colorless, with a slight reddish tone, and usually contain abundant poikilitic inclusions of quartz. The garnets are as a rule later than the other minerals and often inclose, or force themselves between, bundles of sillimanite fibers. They are often lenticular or irregularly embayed, elongated and oriented parallel to the foliation.

Quartz. It is very difficult to distinguish original quartz from quartz introduced by granitic injections. In thin section the quartz grains either interlock irregularly by sutures, often in dovetailed fashion, or form a mosaic aggregate with the other minerals. In several hand specimens the quartz which interlocks by sutures shows a beautiful, delicate, opalescent, blue color. The textures are those characteristic of quartz formed by contact metamorphism, both in this district and elsewhere. (Weinschenk, 1912, 206).

Sillimanite. The sillimanite is usually indistinguishable in the hand specimen. Occasionally, however, glistening cleavage surfaces of the fibrous mineral can be seen. In thin section it appears as long, narrow bundles or sectors of fibers, often in parallel intergrowth with biotite or inclosed, or forced aside, by garnet or cordierite.

Graphite. Graphite seems to be more common in the bluish gray, more quartzose beds than in the others. It occurs as irregular flakes, often in parallel intergrowth with biotite, or, it may occur as an impurity within pyrite or as a thin veneer on the borders of pyrite.

Pyrite. Pyrite is a common accessory mineral. It may occur as irregular grains or with crystal faces. Occasionally it is found replacing chlorite or surrounded by narrow zone of specular hematite.

Biotite-Garnet Gneiss

This rock corresponds closely to that described by Martin from the Canton quadrangle. It has been so intensely injected and disintegrated by pegmatite as to constitute a rather homogeneous belt of pegmatitic gneiss. The Grenville portion of the rock is light bluish gray, and usually contains abundant small garnets. In a portion of

the belt, however, garnets are rare and often confined to the pegmatite veins. In the latter case it is impossible to distinguish this rock in the field from the quartz-biotite gneiss of the northwest; and a discrimination can only be made in this case with a microscope, when it is found that the biotite of the rock from the northwest uniformly has a dark greenish tinge, whereas that of the garnet gneiss belt is pure brown.

The rock, excluding the pegmatitic material, is believed to be of sedimentary origin because of interbedded limestones, as near Bonaparte and Rockwell creeks, because of the presence of occasional thin quartzitic beds and intercalated amphibolitic lenses and sheets similar to those in the Grenville elsewhere, and because of its resemblance to the biotite-garnet gneisses which elsewhere are intercalated in the limestones. At the contact with the California batholith, a remarkably persistent narrow band of contact metamorphic garnet rock has been formed, which will be described later.

The portions of original gneiss which remain fairly well individualized are much finer grained than the pegmatitic material, commonly possess a mosaic texture and consist of biotite, garnet, quartz and feldspar. The quartz grains locally have a sutured texture which, like a mosaic texture, is characteristic of contact metamorphism.

Quartz-Biotite Gneiss

This rock is commonly a dark gray to black gneiss, locally light gray, injected to a variable degree by pegmatite veins. The latter are peculiar because of the striking shapes which they have assumed, irrespective of the gneissic structure of the intruded rock. They often have serpentine or zigzag and crenulated forms, or complicated puckers. In much of the rock the irregular character of the veins does not give the appearance of the ordinary injection gneiss. Locally, however, it assumes the normal character of such a rock. The gneiss is marked by an abundance of little seams and vugs of quartz, tourmaline, muscovite and feldspar, which are exceedingly conspicuous for their size on account of the brilliancy of the shining muscovite plates.

In thin section the rock is seen to be composed of feldspar, most of it poorly twinned, quartz and biotite, with muscovite, apatite and zircon as accessory minerals. The biotite is dark brown, with a greenish hue, quite unlike that of any other gneiss in the district, and constitutes between 15 and 20 per cent of the rock. A little muscovite is in parallel intergrowth with it. The feldspar is mostly oligoclase (Ab_4An_1), with a little orthoclase,

A chemical analysis of a specimen of the rock, as free from pegmatitic material as could be obtained, is given below (no. 1). It is from the central part of the mass, just north of the border between this district and the Gouverneur quadrangle. A partial analysis (no. 2) of a rock from the same mass about a mile south of the Shantyville school is also given.

Chemical analyses of quartz-biotite gneiss

	1	*2*
SiO_2	70.08	70.77
Al_2O_3	15.11	15.73
Fe_2O_3	1.09	3.62
FeO	2.80	
MgO	1.10	
CaO	1.65	1.10
Na_2O	4.31	
K_2O	2.96	
H_2O +	.37	
H_2O —	.16	
	99.63	
Sp. gr.	2.723	

Analyst: A. F. Buddington

This rock is so obscure in both its field relations and its microscopic character that one hesitates to express an opinion concerning its origin. Professor Cushing has suggested[1] the possibility that it has resulted from the alteration of gabbro or amphibolite, residual portions of which are still present in the gneiss. The chemical composition of the rock, however, hardly warrants such an interpretation. The junior author, when in the field, assumed the rock to be granitic in origin and the amphibolite remnants to be inclusions. The chemical composition of the rock is compatible with this hypothesis, as are also the complete absence of hornblende and augite, and the sharp borders of the included amphibolite masses; but the mineral composition is as different from that of normal granite as the chemical composition is from that of normal gabbro. It has already been stated that the rock is more massive and uniform than any of the sedimentary gneisses, and is characterized by a different mica. The writers would suggest that it may have resulted from a relatively complete reaction in depth of a granite magma with a body of basic rock, accompanied by some differentiation and subsequent intrusion to higher levels.

1 Personal communication.

IGNEOUS ROCKS

Gabbro Amphibolite

The main gabbro masses occur as bosses in the limestones, and as long narrow sill-like sheets within the gneisses. Thin sills, too small to map, occur in the pegmatite gneiss around the border of the Edwards mass of mixed rocks and elsewhere in the Grenville gneisses. In certain cases it is difficult to say whether the rock under consideration is a gabbro or a pyroxene gneiss of metamorphic sedimentary origin. In general, however, the gabbro bodies are more massive, uninjected by pegmatite veins and without the appearance of a bedded structure. The pyroxene gneisses, on the other hand, are often well foliated, and those which most resemble the gabbros are often found to carry hypersthene, a mineral which has not been found in the gabbros.

The gabbro mass east of Geers Corners has been previously described in detail by the senior author (1895, 268–170) and this description is repeated below, since the other gabbro masses are similar, except that they lack the primary banding which characterizes this one. In some of the gabbros finer grained varieties have been found to intrude coarser grained phases; but this is a local phenomenon, and all are considered to be of essentially the same age.

Mineralogic composition and characteristics. The microscope shows the rock to consist of plagioclase feldspar, pale green augite, hornblende, biotite, apatite, pyrite and alteration products. All of the minerals, save the apatite, are allotriomorphic, although in the feldspathic variety the augite has an imperfect prismatic habit. The augite is normally the prevailing ferro-magnesian constituent, although it may be replaced by hornblende. The relation between the two is interesting; for if it is ever safe, in the absence of idiomorphic boundaries, to say that massive hornblende is derived from pyroxene, it may be stated in this case. Every stage of the process is clearly shown, beginning with the appearance of small spots of deeper color scattered through the light green of the pyroxene, and ending with a complete substitution of hornblende. The change does not begin in any particular portion of the pyroxene, but at numerous points scattered through the mass. Professor Iddings has pointed out the need of caution in accepting such an explanation of the origin of hornblende, but in the present instance the facts are very strong in its support.

The extinction angles of the feldspar indicate the prevalence of an acid labradorite; but in portions of the rock having an abnormally small amount of ferromagnesian minerals and containing some quartz, there is a much more acid plagioclase and probably some orthoclase. The feldspar, of all the specimens, is entirely free from the fine inclusions so common in the feldspar of most gabbro.

The feldspar is often altered to kaolin and to muscovite, more rarely to scapolite. This latter change is interesting, recalling the group of scapolite-diorites and "gefleckter gabbros." It is also suggestive in connection with the scapolite rock of Gouverneur previously described by the writer. A peculiar feature of the gabbro, considering its rather basic character, is the almost complete absence of magnetite and ilmenite, these minerals being rarely seen in micro-sections.

Gneissoid Monzodiorite-Syenite-Granite Complex

The gneissoid igneous complex which occupies the southeastern half of the quadrangle extends into the unmapped areas on the south, southeast and southwest, and constitutes but a part of the outer portion of a much larger mass.

The northwest portion of the complex has been previously described by the senior author (Smyth, 1895 and 1899) and is here called the Diana mass. The southeastern portion is dominantly of granosyenitic character with small syenite lenses, and possesses a texture and character of metamorphism different from that of the Diana mass. For purposes of description it may be termed the Croghan mass.

The Diana syenitic mass (including monzodioritic and granosyenitic variants), excluding dikes and sills in the Grenville series, and considering only the main body, occupies about 77 square miles, and the Croghan granosyenitic (including variants) mass, about 32 square miles, making a total of about 109 square miles. It is possible that the Diana mass and the Croghan mass represent portions of two separate batholiths.

There are many factors which make it very difficult to choose a satisfactory classification for the igneous rocks of this composite or complex batholith. The rocks of the Diana mass are in general coarsely porphyritic and so crushed that it is impracticable to apply the Rosiwal method to their determination. Again, the feldspars of both the Diana and Croghan masses present grave difficulties. Usually some or most of the plagioclase is in microper-

thitic or cryptoperthitic intergrowth with the potassic feldspar and the latter holds considerable of the albite molecule in solid solution. All the variants less siliceous than the granosyenites are characterized by a large percentage of microperthite and thus give a syenitic aspect to the entire batholithic complex. On the other hand, the analyses show that the series has affinities, chemically, with the monzonitic family varing from monzodiorite through monzonites and quartz monzonites to alkalic and highly siliceous quartz monzonities or granites. But the rocks in general are highly feldspathic and have a relatively greater percentage of alkalies than the typical monzonitic rocks of the western part of the United States. It has been the custom of all workers in the Adirondacks to refer these rocks to various facies of syenite, granosyenite and granites. This usage is retained in this report and the monzonitic affinities of the rocks are indicated in parentheses.

The variants of this igneous complex are mapped as augite-hypersthene syenite, basic augite syenite, augite syenite, hornblende syenite, hornblende granosyenite, hornblende-biotite granosyenite and granite. All the variants less siliceous than the granosyenites are characterized by a large percentage of microperthite, and are therefore distinctly monzonitic in character. Thus the augite-hypersthene syenite is more precisely a monzodiorite, and the basic augite syenite is in part monzodiorite, or monzonite. On the chemical basis of classification, it is Andose. The augite and hornblende syenites are prevailingly monzonite with variations toward quartz-monzonite and syenite. According to the chemical classification, they would be mainly monzonose-akerose, pulaskose or toscanose. The rocks mapped as granosyenite are adequately characterized by this name, though they vary on one hand into quartz-monzonite and monzonite, and on the other hand into granite. In the chemical system they would be classed as Toscanose. The granite is Liparose.

The rocks are prevailingly banded and foliated and, owing to this pseudo-bedded appearance, were originally classed as sedimentary beds; but on the basis of their intrusive relations to the Grenville series, their chemical composition, and their texture and structure, they were shown to be of igneous origin by the senior author (Smyth, 1895). It was also shown that in this mass there is a distinct transition from a basic gabbroic syenite (monzodiorite) to a quartzose hornblende gneiss (granosyenite). This transitional character between the rock types when accentuated, as it is very frequently, by the irregular character of the gradation, makes a definite

boundary between facies impossible, and consequently the mapping of separate types becomes a more or less arbitrary matter. Furthermore, it is often impossible to make close distinctions in the field, and subsequent laboratory study must be depended upon. As a result of these difficulties, the mapping of the variants is no more than a rough approximation to the actual conditions.

Types. A brief tabular statement is given below of the names and typical character of all except one of those facies of the syenite-granite complex which have been mapped. The Carroll School fine-grained granosyenite is not included because of lack of data.

Variants of monzodiorite-syenite-granite complex

	No. 1	*No. 2*	*No. 3*	*No. 4*	*No. 5*	*No. 6*	*No. 7*	*No. 8*
Area: square miles	0.25	2.4	10.3	30.5	30.2	3.5	23.2	1.5
Color	Black	Green	Green	Green	Red	Red	Red	Red
Sp. gr.		2.862 to 3.071	2.765 to 2.851	2.675 to 2.765	2.669 to 2.760	2.624 to 2.690	2.634 to 2.704	2.628 to 2.634
No.[1]		3	11	21	27	9	25	2
Av. sp. gr.		2.895	2.801	2.73	2.712	2.677	2.655	2.631
Quartz	Absent	Trace	Trace	Few%	Up to 10%	10 to 20%	10 to 25%	25 to 40%

No. 1 Hyperite or diabase
No. 2 Augite-hypersthene syenite (monzodiorite)
No. 3 Basic augite syenite (monzonite in part)
No. 4 Augite syenite (monzonitic in part)
No. 5 Hornblende syenite (monzonitic in part)
No. 6 Porphyritic hornblende granosyenite, Diana mass
No. 7 Hornblende-biotite granosyenite (quartz monzonite), Croghan mass
No. 8 Hornblende-biotite granite, Croghan mass

In addition to the facies thus mapped, there are numerous narrow dikes of fine-grained hornblende syenite, hypersthene syenite and hyperite with a diabasic texture, as well as the sheets and dikes of granite and granosyenite, all of which are genetically associated with the syenite batholith and were intruded during the later stages of its consolidation. There are, furthermore, along contacts with the limestone beds and gneisses of the Grenville series, numerous pegmatite veins of granitic character, which are offshoots of the syenite.

Banded character. A dominating feature of these syenitic rocks, as seen in the Lake Bonaparte quadrangle, is their banded and foliated character. The latter will be described later. The former, as indicated on the map, occurs on a large scale in terms of miles; but also in the field it may be seen to be present on a small scale, in units of hundreds or scores of feet, or, on a smaller scale, in terms

[1] Number of determinations of specific gravity.

of feet or tens of feet, and rarely, on a minute scale, in units of less than an inch.

Looked at in a very broad way and disregarding obvious exceptions, there are three general subdivisions or wide bands, which are increasingly more acid towards the southeast, comprising in successive order, augite syenite, hornblende syenite and hornblende-biotite granosyenite. Although this may be regarded as the major structure, the variations within each band are equally apparent and cover an equally wide range of composition, each great band showing a variation from most basic to most acid — from basic syenite to granosyenite — although not always of sufficient size to map.

Banding of augite syenite division. The banding of the augite syenite may be due to any one of three causes; a color banding concomitant with a change in composition, a variation in the percentage of quartz, or a variation in the percentage of augite, usually attended by a corresponding variation in the percentage of magnetite. A narrow band of basic character runs through the central portion of the augite syenite. Its basic character is due in part either to an increase of its augite content, with a corresponding increase in the calcic character of the feldspar, or to an increase in the calcic character of the feldspar without an increase in the augite content. A band of quartz-bearing augite syenite occurs along the northern side of this mass, beween it and the Grenville and within the Grenville. Normal augite syenite, with some acid bands, comes in along the south side, between it and the hornblende syenite.

The green augite syenite, near its contact with the red hornblende syenite, is frequently interstreaked or interbanded in green and red; as is the case along the railroad southwest of Natural Bridge, along the road south from Goose pond about 2 miles east of Harrisville and conspicuously so at the south end of the Aldrich School mass of green syenite, which frays out parallel to the foliation into the red syenite. These bands, although appearing with parallel walls in a given local zone, must be lenticular in character when considered for long distances, since the succession of bands is different in cross sections taken at considerable distances apart along their line of strike. Furthermore, the variation in color banding takes place very sharply, for repeatedly normal green and normal red phases were traced to within distances of from several feet to a score of feet from each other without any apparent change in hue.

At the contact of the Aldrich School mass of green syenite and the red syenite, to the north, there is some color banding on a large scale, and interstreaking on a small scale. A road cutting here

exposes a fresh surface 10 feet wide in which a gradation may be traced, in streaks of intermediate hues, from the normal green to the normal red color. Yet, although there is this gradation, nevertheless the streaks themselves are sharply defined against each other but absolutely without evidence of intrusive contacts. The gradations are irregular, discontinuous and abrupt. It may be also noted here that the rock of this outcrop, as a whole, is transitional between the hornblende syenite and the augite syenite, containing hornblende and augite in about equal proportions.

The amount of augite varies greatly and abruptly in the syenite. An increase in augite in the more basic phases is generally accompanied by a corresponding increase in the magnetite content. Locally there are bands, or lenses, excessively rich in augite and often as sharply defined as dikes or sills. Such a lens, about 1¾ miles south of Harrisville, shows to a high degree the banding due to a variation in the augitic content. At one place a band of almost black-weathering syenite, about 40 to 50 feet thick, very rich in augite and with considerable magnetite, lies between bands of normal light gray syenite. The contact between the two rocks is sharply defined, yet it is not an intrusive contact. The highly augitic band, in turn, shows a finely streaked character and is but one of many such basic augitic-magnetitic bands in the normal syenite at this locality. Small, elongated segregations, varying up to several feet in length and consisting of augite-rich bands bearing magnetite, are also common in the syenite. From this extreme the augite content of the different bands may decrease to a position of subordinate importance as a constituent of the rock, in which case the feldspar becomes almost the exclusive mineral of the band, resulting in variations from highly feldspathic bands to highly augitic bands. These latter variations are on such a scale and usually so inconspicuous that they may be easily passed over in the field.

These bands are always, so far as observed, parallel to the local foliation of the rocks, both in the case of the color banding and in the case of the mineral or composition banding.

Banding of hornblende syenite division. The banding of the red hornblende syenite is even more apparent than that of the green augite syenite, owing to its lighter color, permitting mineral variations to become more conspicuous. Inclosed within this division is an elongated, lenticular band of green augite syenite which in turn incloses a smaller, lenticular core of red hornblende syenite. The composition variation in this division, without any intrusive character being apparent, is wide, ranging from a granosyenite to a basic

augite-hypersthene syenite. The banding within the green syenite lens is similar to that of the main band just described.

The banding of the red syenite is due to variations in shade of color, in the color of the feldspar phenocrysts, in texture and in the quartz and hornblende content.

The color change is dominantly that of a variation in the intensity but is frequently due to the acquisition of a greenish hue. The feldspar phenocrysts, which are often very conspicuous, may characterize certain bands by their consistent flesh red color, or by a mixture of flesh red and yellowish green individuals, as the case may be. The latter type forms a well-characterized facies of considerable volume.

The variation in texture of different bands is often quite striking. One may be a typical porphyritic augen gneiss, while another is almost equigranular or rarely the hornblende may take the place of the feldspar as phenocrysts. This is not a primary, but a secondary feature, however. The variation in hornblende content of the different bands in the red syenite is as marked as the variation of the augite component is in the green syenite mass previously described, while the increase and diminution of the quartz content is even more conspicuous and more accentuated, ranging back and forth from an almost total absence up to 20 per cent in exceptional bands.

The banded character of the rock is very well shown along the road from Kimball Mill to Tinney Corners, which crosses the strike of the foliation approximately at right angles, and where the succession of outcrops is a succession of rocks no two of which appear absolutely the same, each showing some character, either color, mineral composition or texture, different from the preceding, and varying in composition from a basic augite-hypersthene syenite to a granosyenite. A slight complication, however, is added here by the presence of intrusive dikes and sheets of hornblende granite and by the possibility that some of the granosyenite sheets are intrusive parallel to the foliation.

The parallelism of the banding and the foliation or cleavage is, so far as observed, quite consistent. Even where the edges of the blunt ends of some bands are at a considerable angle to the prevailing trend, as north of Sunday swamp and north and south of Middle Branch Settlement, the foliation of both bands can be seen to curve around parallel to the contact lines.

Banding of hornblende-biotite granosyenite division. The large scale banding of the granosyenite is far less conspicuous than

that of the two preceding divisions, with the exception of the mapped augite hypersthene syenite band. The banding due to color and textural variations has almost completely disappeared. The composition variation here is, however, the most extreme, ranging from the basic syenite to siliceous granite.

The banding, aside from the foliation and the mapped syenite band, is due to a variation in the quartz and to a progressive decrease in the hornblende and biotite content toward the southeast. These variations are inconspicuous on a fresh surface but are prominent on a weathered surface. In going across the granosyenite mass, through the woods to the southeast, one repeatedly finds bands showing but a moderate or wholly inconspicuous amount of quartz with considerable hornblende and biotite, and others which appear very granitic with but a trifle of ferromagnesian mineral. Occasional small, elongated segregations of augite and magnetite still persist in the granosyenite. Also, what appears to be the northern termination of a lens of normal hornblende and augite syenite begins to appear just south of Jerden Falls.

General character of banding. The essential features of the remarkable banding of the syenitic rocks of this quadrangle may be summarized as follows:

The banding may be due to mineral variation in which augite, hornblende and quartz play the leading parts, with or without accompanying marked color changes.

The banding, no matter what the scale, is always parallel to the foliation or cleavage, so far as observed. Where the end of a band is blunt and its edge is at a considerable angle to the prevailing strike, the foliation swings around parallel to the border of the band. Where the banding changes from the prevailing northeast strike to an almost north strike, as in the south, or to an east-west strike, as in the west, the foliation still is parallel to it. The straight border of the southeast end of the Aldrich School mass of green syenite is only an apparent exception to this rule, as the green mass really frays out into the red, parallel to the divergent foliation, in a very intimate manner but on too small a scale to be mapped.

The bands are lenticular in character as shown on a large scale by the mapping and on a small scale by the elongation and disappearance of the bands parallel to the foliation, as observed in the field.

The individual color bands or streaks are sharply delimited from each other at their contacts, although gradation by intermediate steps, which are in turn themselves sharply defined, may be present.

Again, in the case of bands very rich in augite, and in segregations of augite and magnetite, contacts were observed to be sharp.

The line of junction between these bands does not represent a line of contact due to successive intrusions.

Contacts between mineral facial bands are, in general, gradational, but the gradation appears to be very rapid.

To a slight extent there may have been some intrusion of granosyenitic facies parallel to the foliation, subsequent to, at least, the partial consolidation of the more basic phases.

General textures and structures. In addition to the banded character, just described, the syenitic rocks are foliated to a very considerable degree, dominantly parallel to the general NE-SW trend of the formations. As mentioned before, the southeastern portion, or Croghan granosyenite mass, differs in both primary and secondary characteristics from the Diana syenitic phase in the northwest. The texture of the Diana phase—quickly chilled contact stuff excepted—is dominantly coarsely porphyritic or lenticular, often forming a typical augen gneiss; while that of the Croghan phase is approximately equi-granular. Within each body the texture is constant, despite widely variant mineral facies.

Diana banded syenitic mass. These rocks have been previously described (Smyth, 1895) and, in a slightly revised form, this description is repeated here. They constitute a band about 5 miles wide, occupying an area of about 76 square miles, forming the northwestern portion of the general body of syenitic rock. In composition they vary from an augite-hypersthene syenite and basic augite syenite (Andose) to a granosyenite (Toscanose), and in specific gravity from 2.624 to 3.071, with an average for the whole mass of about 2.73.

Appearance in the field. Over a large proportion of the syenite belt outcrops are abundant. The rock surface usually presents flowing contours, with something the aspect of roches moutonnées. This is particularly true in the eastern part of the belt, where the syenite rises into considerable hills. In the vicinity of Natural Bridge the surface is flatter.

The rock is dominantly porphyritic, or lenticular, in texture, except along contacts with the Grenville, where it was quickly chilled and solidified with a more or less equigranular texture.

The mass has been subdivided on the basis of mineralogic composition into augite-hypersthene syenite, basic augite syenite, normal augite syenite, normal hornblende syenite, augite granosyenite and hornblende granosyenite.

Normal syenite. The term "syenite" has been defined by Iddings (1909, 362) as a rock composed chiefly of alkali-feldspars, with subordinate amounts of ferromagnesian minerals, and sometimes small amounts of lime-soda feldspars, quartz or feldspathoids. Under this interpretation, about four-fifths of the Diana mass, or about 61 square miles, is normal syenite, and the remaining one-fifth comprises the basic syenite band and the small granosyenite lenses. This normal syenite passes gradually, on the one hand, into the basic augite and augite-hypersthene syenite and, on the other, into the granosyenite. The normal syenite itself has been subdivided into green augite syenite and red hornblende syenite.

Significance of red and green colors. The normal syenites were split into these two subtypes, in the field, on the basis of the red and green colors alone. It was recognized, however, that the red syenites were prevailingly more siliceous than the green. A laboratory study of numerous thin sections has proved that the green rocks are almost exclusively augite syenites, while the red rocks are as dominantly hornblende syenites. Gradational types of hornblende-augite character occur along the borders of the two facies. The more siliceous character of the red syenites is also confirmed by microscopic study.

Characteristics of the feldspars. In form the feldspar grains may be rounded or nearly rectangular, approaching their crystallographic outlines. A zonal structure is often shown, the marginal portion being nearly white, while the interior is gray or brown. The white band is about one-fourth as wide as the individual and the passage into the dark core is rather abrupt. There is a marked difference in the resistance offered to decay by these two portions of the feldspars. The dark area decomposes much more readily; so that on glaciated surfaces which have been slightly weathered, the feldspar grains have a depression in the central portion, surrounded by a rim of the white material. This differential weathering is due to the more ready solubility of the more calcic plagioclase, which usually forms the core of the zoned feldspar, in contrast to the microperthite, forming the border (plates 8 and 9, upper figures). In the more basic facies of the syenite these calcic cores of the feldspar have such a high degree of translucency on a fresh surface as to resemble quartz at a hasty glance. The pitted character of the phenocrysts may be observed in the more siliceous, as well as the more basic, facies of the syenitic mass.

Augite hypersthene syenite (monzodiorite). A long, narrow lens of very basic, gabbro-like rock is present in the granosyenite near Tinney Corners. It is not known definitely, owing to an inter-

vening cover of sand, whether this mass is a continuous lens or whether it comprises two lenses, with a break between them, north of Norman pond. The rock is similar, mineralogically, to the dikes of hyperite which cut the syenite and, as no contacts of this mass with the country rock have been seen, it may be that it is but a large dike or elongated stock. The fact, however, that at two localities hornblende syenite has been found to intervene between it and the granosyenite indicates that there is a gradual transition between them and that the basic phase is merely one of the many sharply differentiated bands within the batholith. In either case the rock is but a differentiated facies of the syenite. The specific gravity of the rock is high, two determinations on average specimens giving 2.929 and 2.826, respectively. In many ways it is transitional in character between the basic augite syenite and the hyperite.

Texture. The rock is very coarse grained, weathering to a dark gray. It is either lenticular or diabasic in texture, with grains of feldspar averaging half an inch in diameter in a black mesh of pyroxene, associated with considerable magnetite. The rock from the northern half has the appearance of having been originally more or less equigranular, but that of the south has a conspicuous diabasic texture.

Mineral composition. The rock is composed essentially of andesine feldspar and of hypersthene and augite, with orthoclase, magnetite, quartz, apatite and microcline as accessory minerals. Part of the augite and hypersthene is in parallel intergrowths, and some of the orthoclase exhibits granophyric intergrowths of quartz. All the minerals, except quartz, are considerably granulated, with large residual cores of andesine, hypersthene and augite. A considerable proportion of the granulated pyroxene is altered to hornblende.

Occasional veins of andesine, resembling anorthosite, are found traversing the rock.

Chemical composition. An analysis of a typical specimen of this variant of the syenite from a locality about 1 mile south of Tinney Corners is given below.

Chemical composition and norm of augite hypersthene syenite (monzodiorite)

	No. 1	*Norm*	
SiO_2	50.66	Albite	36.7
Al_2O_3	17.51	Orthoclase	13.1
Fe_2O_3	5.57	Anorthite	21.8
FeO	6.21	Diopside	10.6
MgO	2.92	Hypersthene	1.1
CaO	7.66	Olivine	3.8
Na_2O	4.36	Apatite	1.3
K_2O	2.22	Magnetite	8.1
H_2O+	.32	Ilmenite	2.9
H_2O-	.14		
TiO_2	1.59		
P_2O_5	.58		
	99.74		
Sp. gr.	2.929		

Analyst: A. F. Buddington

A transitional phase between the hypersthene-bearing rock and the normal syenite is found for several miles along the south border of the augite syenite mass near Sunday swamp. This rock is a porphyritic, basic syenite consisting of oligoclase-andesine, microperthite, hypersthene and augite.

A still more basic phase of the syenite batholith, of real gabbroic character, occurs in small volume about ½ mile east of Onjebonge pond. It is a coarse, equigranular, greenish rock of typical syenitic aspect, and occurs as a phase of the syenite. It consists of labradorite and hypersthene, the latter considerably altered to hornblende and biotite.

Basic augite syenite. This syenite differs only in degree from the augite syenite and hence will be treated briefly.

It forms a long, narrow band within the normal syenite, from ½ to ¾ of a mile wide, and its delimitation from the latter is purely arbitrary since there is a gradual transition between the two varieties. Narrow bands of exceptionally basic character, from a score of feet to 100 feet wide, occur within the mass, as well as small, elongated basic segregrations. The latter are locally quite abundant but usually infrequent. They are very rich in augite and magnetite and usually show a slight concentration of the accessory minerals, such as titanite and apatite. Normal augite syenite also occurs in this band. The typical rock consists of microperthite, plagioclase and augite, with considerable magnetite and quartz, zircon and apatite as accessory minerals. The large feldspars are zoned, and the plagioclase may vary from labradorite at the center to oligoclase in the outer zones, with an outermost border of microperthite.

Chemical composition. The following is an analysis of a specimen from near Natural Bridge:

Chemical composition and norm of basic augite syenite (andose)

	No. 2	*Norm*		*Mode (monzodiorite)*	
SiO_2	57.00	Orthoclase	21.1	Feldspar	76.0
Al_2O_3	16.01	Albite	36.7	Augite	13.6
Fe_2O_3	6.71	Anorthite	13.9	Hornblende	3.7
FeO	5.08	Quartz	4.4	Magnetite	3.6
MgO	1.62	Diopside	13.8	Quartz	2.5
CaO	6.20	Hypersthene	1.0	Apatite	0.7
Na_2O	4.35	Magnetite	9.7	Titanite	0.1
K_2O	3.53				
H_2O	.13				
	100.62				
Sp. gr.	2.851				

Analyst: C. H. Smyth jr.

Augite syenite (monzonitic). This variant forms, by a narrow margin, the greatest area (30½ square miles) within the syenitic body. In this quadrangle it is confined to the Diana mass. It may occur as long narrow bands within the hornblende syenite, or it may itself inclose bands of more basic syenite or of hornblende syenite.

Weathering. The weathered surface is usually a light drab or gray, while the thin weathered zone immediately beneath the surface is prevailingly brown, locally of a maple sugar color; and fresh green specimens can usually be obtained only in road cuttings or along unweathered joints. It often happens that where a superficial coating of moss has been removed, the weathered surface is white, or, on removing an isolated moss plant, the delicate tracings of the rootlets are seen outlined in white against a gray background. Locally, rusty spots are common in the syenite, due to oxidation of pyrite grains.

Texture. The weathered surface usually shows a somewhat porphyritic aspect; that is, the rock appears to consist largely of feldspar crystals, dominantly over ⅜ inch in length and varying up to 1 inch or more, set in a meshwork of finer material, consisting of a variable amount of black augite and peripherally crushed material. The texture is dominantly lenticular, or similar to that of an augen gneiss. The ratio of augen to groundmass is inconstant, varying from about 80 per cent down to a few per cent. The original porphyritic texture has been either accentuated, diminished or altered to a lenticular appearance by the subsequent crushing to which the rock has been subjected.

Mineral composition. The variability of the composition of the

3

syenite has already been mentioned. That portion forming the northern part of the mass, along the border of the Grenville series, is prevailingly siliceous, carrying free quartz in amounts up to 10 per cent or more, as are likewise those facies on the border of the grano-syenite masses. Two analyses of this quartzose type will be found on a succeeding page. The dominant rock, however, is more basic, with but a trace of free quartz, appearing inconspicuously on a fresh surface. An analysis of a type especially prevalent south and west of Harrisville will be given later. The quartzose type falls in the rang Toscanose of the C. I. P. W. classification, but the dominant type varies between rangs akerose, monzonose, laurvikose and pulaskose.

The dominant mineral is microperthitic feldspar, often inclosing a core of plagioclase or associated with plagioclase, the latter usually oligoclase. The microperthite may increase until it becomes the only feldspar present.

The ferromagnesian mineral is almost exclusively a deep green, nonpleochroic, monoclinic pyroxene, locally altered to secondary hornblende or rarely to biotite. Primary hornblende is practically absent in typical specimens but increases rapidly in the transition zones into hornblende syenite. Magnetite is a quite variable constituent, ranging from small inclusions in the feldspar up to irregular masses, of considerable volume, molded against the other constituents. It is noteworthy that when the magnetite does not form more than a few per cent, it was among the first minerals to crystallize; but that when it exceeds a few per cent it was, for the most part, the last mineral to crystallize, and is interstitial in its relations to the other constituents.

Quartz is exceedingly variable in amount and was the last mineral to crystallize. It is always present but typically does not form more than a small percentage of the rock, rarely exceeding 10 per cent.

Apatite is a prominent accessory, associated closely, as a rule, with the magnetite. Zircon, in slender rods and stout crystals, is always present. Titanite, hematite and ilmenite are occasional constituents. Pyrite, in small grains or nodules, is common.

Contact phases of the syenite show variations which will be described later.

Chemical composition. Five chemical analyses of this facies of the syenite will be found below. Numbers 6 and 7 are of the more siliceous facies, along the northern border; whereas numbers 3, 4 and 5 represent the dominant characteristic types, number 4, in particular, being chosen in the field as representing a type of widespread

occurrence. Number 3 is traversed by minute veinlets of calcite, and it is not certain to what extent they may represent some decomposition of the rock.

Chemical analyses of augite syenite

	No. 3	*No. 4*	*No. 5*	*No. 6*	*No. 7*
SiO_2	55.68	59.41	61.91	63.11	65.65
Al_2O_3	18.99	18.31	17.64	18.02	16.84
Fe_2O_3	2.02	3.27	3.55	2.12	2.56
FeO	2.92	3.01	2.19	3.53	2.02
MgO	1.30	1.13	.89	1.43	.13
CaO	6.29	4.20	3.60	2.56	2.47
Na_2O	5.26	5.32	4.51	4.08	5.27
K_2O	4.06	4.91	5.22	4.26	5.04
H_2O+	.54	.19	.98	.26	0.30
H_2O-	.13	.13	.16	.09	
CO_2	2.62	......	......	......	......
Total	99.81	99.88	100.65	99.46	100.28
Sp. gr.	2.735	2.758	2.700	......	2.677

No. 3 On road, 1½ miles south of Natural Bridge. Analyst: A. F. Buddington
No. 4 Three-fourths of a mile south of Harrisville. Analyst: A. F. Buddington
No. 5 On road, 1⅝ miles south of Natural Bridge. Analyst: A. F. Buddington
No. 6 Near milestone 56, Carthage and Adirondack R. R. Analyst: R. W. Jones
No. 7 One and one-fourth miles southwest of Harrisville. Analyst: C. H. Smyth jr

Norms calculated from chemical analyses of augite syenite

	No. 3	*No. 4*	*No. 5*	*No. 6*	*No. 7*
Orthoclase	23.9	28.9	31.1	25.0	30.0
Albite	44.5	45.0	38.3	34.6	44.5
Anorthite	14.5	11.7	12.2	12.8	7.2
Quartz	......	......	7.2	13.2	10.5
Corundum	.6	......	......	2.0	......
Diopside	......	7.6	4.5	......	3.6
Hypersthene	6.8	1.7	1.1	8.4	......
Magnetite	3.0	4.9	5.1	3.0	3.7
Calcite	6.0	......	......	......	......
Wollastonite	......	......	......	......	.3

No. 3 Laurvikose?
No. 4 Monzonose-Akerose, (11, 5, 2, 3–4)
No. 5 Pulaskose, (1, 5, 2, 3)
No. 6 Toscanose, (1, 4, 2, 3)
No. 7 Toscanose, (1, 4, 2, 3)

Physical character. The specific gravity of the normal augite syenite ranges from 2.675 to 2.765, with values between 2.70 and 2.76 dominant. An average of 15 determinations of syenite, showing but rare quartz in the hand specimen gave a value of 2.729, and an average of 6 determinations of the quartz-bearing type, a value of 2.681. The value of 2.765 was chosen as the upper limit of the normal syenite since, if in the rock represented by analysis No. 4, which has a specific gravity of 2.758, there was a very slight increase

in the percentage of CaO and Na_2O with respect to K_2O, it would throw the rock into the rang Andose, which is typically basic. A partial analysis of a rock with a specific gravity of 2.801 gave 56.6 per cent SiO_2 and 6.29 per cent CaO. The specific gravity, in general, has been found to correspond to the basicity of the rock, but exceptions may be found, such as the augite syenite described by Cushing (1907, 514), which has a silica percentage of 59.7 but a specific gravity of only 2.674.

It is difficult to arrive at an estimate of the average specific gravity of this facies, considered as a whole, but it probably lies between 2.72 and 2.73.

The following characteristics of a specimen from milestone 55, Carthage and Adirondack Railroad, are given by Newland (1916, 89): specific gravity, 2.705; weight, pounds a cubic foot, 169; absorption, pounds a cubic foot, .07; hardness, 18.1; toughness, 15; ratio of absorption .148 per cent; pore space .402 per cent.

Hornblende syenite (Monzonitic). This facies of the normal syenite is similar to the augite syenite, except that hornblende takes the place of augite and the rocks contain somewhat more quartz. Although the color change of the rocks along the border is abrupt, the mineral composition shows gradations and here the ferromagnesian minerals, hornblende and augite, are about equal in amount. The rock is reddish, weathering locally to light gray.

Texture. The rocks show a prevailing lenticular, or augen gneiss, texture, in which the augen vary from 85 per cent of the rock to scarce residual cores, a result of granulation. There are two prevalent types, one a rock with a coarse lenticular texture, with red and green eye-shaped feldspars, in a black meshwork of hornblende; the other an apparently equigranular, medium-grained rock with rare augen.

Mineral composition. As in the augite syenite, microperthite is the dominant mineral. Plagioclase, usually oligoclase, is present in variable amounts and often forms a core at the heart of the microperthite feldspars. The feldspar content varies from 75 to 90 per cent.

Hornblende is always the dominant ferromagnesian mineral, except at the border of augite syenite masses and in typical specimens is present to the exclusion of pyroxene. It varies in volume from several per cent up to about 15 per cent.

Quartz is always present but varies from occasional grains up to 10 per cent. Augite, of similar character to that in the augite syenite, is present locally as an accessory mineral. Magnetite exhibits a

range and character of distribution similar to that in the augite syenite. Apatite and zircon are omnipresent accessory minerals and locally occur in surprising abundance in the segregated hornblende streaks. Titanite, ilmenite and hematite are occasionally present.

The red color of these syenites is due partly to finely divided hematite which in large part borders the edges of the feldspar grains. Its origin is uncertain. Occasional minute grains of specular hematite occur in the feldspars, along with some hematitic dust and clots, but these do not materially contribute to the color of the rock.

Chemistry. An analysis of a specimen of typical hornblende syenite, from a locality about 7/10 mile southeast of the French Settlement school, is given below. This rock is porphyritic, with green and red phenocrysts and considerable free quartz. Lines of black hornblende are prominent. It was chosen, in the field, as being characteristic of a large portion of the hornblende facies.

Chemical analysis and calculated norm of hornblende syenite

No. 8		*Norm ; Monzonose near Pulaskose*	
SiO_2	64.41	Orthoclase	30.6
Al_2O_3	15.69	Albite	40.3
Fe_2O_3	2.46	Anorthite	6.1
FeO	2.64	Quartz	9.5
MgO	1.03	Diopside	6.9
CaO	2.90	Hypersthene	2.1
Na_2O	4.78	Magnetite	3.5
K_2O	5.12		
H_2O+	.38		
H_2O-	.21		
	99.62		
Sp. gr.	2.721		

Physical character. The specific gravity of the hornblende syenite has a lower maximum and a lower average than the augite syenite. Curiously enough, although often of a more acid character, the hornblende syenites do not show low values of specific gravity as frequently as do the augite syenites. Their range is from 2.69 to 2.76, with values from 2.700 to 2.73 prevailing, and a general average of 2.712 for twenty-seven determinations.

Porphyritic hornblende granosyenite. This rock starts in very sharply, against the normal augite syenite, on the road about 1¾ miles south of Natural Bridge. Following it along the strike, however, a lenticular mass of normal hornblende syenite comes in on the east, and separates it from the augite syenite. Where the rock first appears, it contains only about 10 per cent of quartz, which forms an irregular, interstitial mesh around the coarse feldspar. Some of the phenocrysts weather, like some of those of the augite

syenite, with a depressed core and a raised rim. South of the east-west road through North Croghan, there is a sharp increase in the quartz content, to form a lens of granosyenite about a mile wide, averaging about 20 per cent quartz. The rock is exceptionally well foliated although so siliceous; and the quartz, weathering out in relief, gives to the surface a conspicuous ribbed and granitic appearance. The apparent amount of quartz on a weathered surface, however, is out of all proportion to its actual percentage in the rock. On its southern side this rock appears to be intrusive into the adjoining granosyenites.

Texture. The rock is prevailingly coarse porphyritic, the proportion of phenocrysts to groundmass being quite variable and depending on the degree of crushing which the rock has undergone. Some residual cores are always present. These are lenticular in shape and are usually from ¼ to ½ inch in length, although sometimes larger. The quartz is drawn out into a very closely compressed, elongated meshwork, of a veinous pattern.

Mineral composition. The rock consists chiefly of microperthite and quartz, with some oligoclase and a little hornblende. Magnetite, zircon and apatite are accessories. The oligoclase may occur either as residual cores of phenocrysts or as an inner core of some of the microperthites. The ferromagnesian mineral is usually much chloritized, but seems to have been almost exclusively hornblende. The rock, owing to its coarse grain and excessive foliation, is poorly adapted for the application of the Rosiwal method.

Chemical composition. The following is an analysis of a typical specimen of the siliceous facies, from a point about a mile south of the North Croghan road, and a half a mile east of the western border of the sheet. The rock belongs to the subrang "Toscanose" of the C. I. P. W. classification.

Chemical composition and norm of porphyritic hornblende granosyenite

No. 9		*Norm*	
SiO_2	68.83	Orthoclase	30.02
Al_2O_3	15.81	Albite	37.73
Fe_2O_3	2.08	Anorthite	6.67
FeO	1.11	Quartz	19.98
MgO	.33	Corundum	.51
CaO	1.35	Magnetite	3.01
Na_2O	4.46	Hypersthene	1.06
K_2O	5.04		
H_2O+	.51		
H_2O-	.16		
	99.68		
Sp. gr.	2.669		

Physical character. The specific gravity of the granosyenite varies from 2.624 to 2.690 with an average of 2.67, the result of five determinations.

Augitic variant. The southern half of the granosyenite has slightly different characters from the northern half. It presents in the field a far more granitoid or porphyritic granitoid appearance than the rock of the northern half. In thin section, however, it is seen to be very highly mashed. It weathers to a deep reddish brown, often with a purplish hue. Feldspar forms 70 to 85 per cent of the rock, and quartz from 10 to 20 per cent. The quartz ranges from a pale bluish gray, with a waxy luster, to a colorless vitreous character. The ferromagnesian minerals vary from 6 to 8 per cent and usually consist of aggregates of chlorite, hornblende and biotite which, with magnetite and calcite, are all secondary products. Occasional fresh grains of augite still remain to suggest the original mineral. Inclusions of Grenville, which have almost entirely disappeared as a result of reaction with the granosyenite, are present locally and may account for the anomalous occurrence of augite here.

Croghan granosyentic mass. (Quartz monzonite). This mass is distinguished from the preceding Diana mass by its more siliceous character and its equigranular texture. In mineral and chemical composition, however, it grades into the adjoining hornblende syenite. It covers an area of about 23 square miles and consists almost exclusively of granosyenite. This granosyenite, however, varies progressively toward the southeast, from a rock of more basic character with a specific gravity of 2.696, to a biotite granite with a specific gravity of 2.626. There is a distinct diminution in the percentage of ferromagnesian minerals in the southern half of the mass, although the silica percentage remains approximately the same. The lines of equal specific gravity are, as usual, parallel to the foliation.

The granosyenite contains a long, narrow lens of very basic augite-hypersthene syenite which, although it appears to be directly connected with the abundant hyperite dikes in the surrounding rock, seems also to be but a phase of the granosyenite, a differentiate in place, since in several instances narrow strips of rock of intermediate character, such as hornblende syenite, intervene between it and the granosyenite, and since it is parallel to the foliation. The granosyenite near Jerden Falls locally contains abundant inclusions of Grenville, which it has thoroughly metamorphosed. In an elongated lenticular area a little east of north of Jerden Falls, the granosyenite shows occasional garnets and more hornblende and quartz than

normal, due to a slight reaction with blocks of Grenville. Just south of Jerden Falls a lens of normal hornblende syenite comes in and may enlarge in its continuation southward.

Hornblende-biotite granosyenite. This rock varies from reddish to pink and in many outcrops weathers so that a specimen can be crumbled between the fingers, although the rock is not disintegrated *in situ*. Quartz usually appears conspicuously on a weathered surface, but is masked by the feldspars on a fresh surface. The rock is foliated, and glistening scales of biotite are prominent on cleavage surfaces, although present in only small amounts.

Texture. Although foliated, the texture is approximately equigranular, the grains averaging from 1 to 3 mm in diameter. The dark ferromagnesian minerals and quartz feldspar aggregates, or quartz and feldspar separately, are segregated in streaks or narrow bands. No porphyritic texture has been noticed.

Mineral composition. The dominant mineral is feldspar, which forms from 65 to 80 per cent of the rock. The feldspar, for the greater part, is microperthite, ranging from 40 to 60 per cent, and the remainder is oligoclase, perhaps with some orthoclase, varying from 10 to 30 per cent. Much of the latter feldspar is untwinned but is still apparently plagioclase. The twinning may be traced, fading out into grains in which it is barely perceptible and finally disappearing entirely. In the latter case, the feldspar shows the kaolinization common to the plagioclases and a similar index of refraction, in contrast to the microcline portion of the microperthite. Some of it can be positively identified with the feldspar forming the spindles in the microperthite. Some microcline, without perthitic intergrowths, is locally prominent.

Quartz, in the normal granosyenite, varies from 10 to 25 per cent; in typical specimens, from 15 to 20 per cent.

The ferromagnesian minerals are hornblende and accessory biotite. The hornblende varies from 5 to 10 per cent, and the biotite from a fraction of a per cent to 2 per cent in the northwestern half, whereas in the more siliceous variants of the southeast, both hornblende and biotite together constitute only a few per cent.

Magnetite, apatite and zircons are constant accessories, and locally garnet is present where the magma has reacted with fragments of Grenville.

The period of crystallization of the individual minerals shows considerable overlapping. The accessory minerals, zircon, apatite, and magnetite, were among the first to separate. Small euhedral crystals of hornblende occur inclosed in both feldspars and quartz. The hornblende, however, in part crystallized together with, and

even later than, the feldspars and quartz. Biotite occurs as parallel intergrowths with the hornblende and as inclusions in the other minerals. Plagioclase occurs sparingly both as rounded inclusions in, and as contemporaneous crystallization with, the microperthite. Minute, more or less corroded, hexagonal quartzes commonly occur as inclusions in the hornblende and feldspars and may locally be so abundant as to constitute a poikilitic texture.

The feldspars and ferromagnesian minerals have been affected locally along their contacts by residual magma or by later solutions in such a fashion that a new mineral or group of minerals replaces the corroded portion. Quartz is a common mineral which forms embayments in the edges of the two mineral groups cited. Again, hornblende and biotite have reacted with liquid, feldspar and quartz separating in their place. Another reaction taking place at a late stage was the formation of very narrow borders of plagioclase on one or more of the edges of some microperthite feldspars and occasionally of the large plagioclases. This selvedge may be proved to be plagioclase—it is usually untwinned—by its optical continuity with the intergrowths in microcline microperthite or with the plagioclase itself, depending on whether it fringes microperthite or plagioclase. Rarely this secondary plagioclase occurs in irregular, veinous forms along fractures in the microperthites.

The texture is an interlocking one, such as arises during primary crystallization, and the order of crystallization is that normal to igneous rocks.

Chemical composition. Three analyses of the granosyenite, showing the progressive change in character from its western border eastward, are given below. All belong to rang Toscanose of the C. I. P. W. classification.

Chemical analyses and calculated norms of hornblende granosyenite

Analyses	*No. 10*	*No. 11*	*No. 12*
SiO_2	66.84	69.27	69.40
Al_2O_3	14.91	13.87	15.54
Fe_2O_3	1.88	1.86	1.41
FeO	2.64	2.23	1.27
MgO	.41	.47	.17
CaO	2.28	1.97	1.43
Na_2O	5.01	3.57	3.69
K_2O	5.11	5.70	6.30
H_2O+	.41	.54	.40
H_2O-	.12	.13	.11
	99.61	99.61	99.72
Sp. gr.	2.696	2.669	2.634

Norms (Toscanose)	*No. 10*	*No. 11*	*No. 12*
Orthoclase	30.0	33.9	37.3
Albite	43.2	30.4	31.4
Anorthite	3.1	4.7	7.0
Quartz	13.1	21.5	19.6
Diopside	7.2	4.3	....
Hypersthene	.5	1.6	1.6
Magnetite	2.8	2.2	2.1

No. 10 On road, 1½ miles west of Jerden Falls. Analyst: A. F. Buddington
No. 11 On road, ¼ mile west of Jerden Falls. Analyst: A. F. Buddington
No. 12 1¾ miles east of Jerden Falls. Analyst: A. F. Buddington

Specific gravities. The average of twenty-five determinations of specific gravity gives a value of 2.655 for the whole mass, with a variation from 2.634 to 2.704. An average of eighteen samples from the granosyenite of the northwest half gives a value of 2.671 with a variation from 2.648 to 2.704, and of seven samples from the southern half, a value of 2.638 with a variation from 2.634 to 2.648.

Carrol school hornblende-biotite granosyenite. This forms a portion of a small body in the south central portion of the syenite mass. It is difficult to separate this rock in the field from the granosyenite on the east. The former, however, is fine grained, in contrast to the medium grain of the latter, and is cut by more abundant pegmatite veins. It is mapped separately because it forms a distinct mass and sends off dikes into both the grano-syenite and basic augite-hypersthene syenite.

The rock is a fine grained, red gneiss, locally with pegmatite veins parallel to the foliation. In thin section a specimen of the average rock is found to consist of microperthite 36 per cent, plagioclase 22 per cent, microcline 8 per cent, quartz 25 per cent, hornblende 7 per cent, biotite 1½ per cent, and accessory magnetite and titanite, with an average grain of about 3 mm. There is an inconspicuous tendency towards a porphyritic texture, with slightly larger crystals of feldspar and hornblende, in an equigranular granulitic groundmass. The hornblende is euhedral in small grains, and anhedral in large ones; the biotite is deep green and occurs in long shreds.

Biotite Granite. In the southeast corner of the Lake Bonaparte quadrangle the granosyenitic gneiss rather abruptly grades into a granitic gneiss of siliceous character. This gneiss presents the same banded and streaked arrangement of its mineral constituents as the granosyenite, and in appearance and mineral character is similar to it.

At Bisha's Mill blocks of this rock have been quarried for dam foundations. A specimen from this opening is equigranular, with grains of an average diameter of about 0.7 mm and in thin section is seen to consist almost exclusively of microperthitic feldspar and quartz. The accessory minerals include about 1½ per cent biotite and a trace of sodic oligoclase, with rare zircon and magnetite. A chemical analysis is given below.

Chemical analysis and calculated norm of biotite granite

No. 13		*Norm (Liparose)*		*Mode*	
SiO_2	76.20	Quartz	33.6	Quartz	35.0
Al_2O_3	12.54	Orthoclase	31.1	Microperthite	62.0
Fe_2O_3	.90	Albite	30.4	Oligoclase	1.0
FeO	.56	Anorthite	2.5	Hornblende	0.5
MgO	.08	Diopside	.9	Biotite	1.5
CaO	.73	Magnetite	1.4	Apatite	0.1
Na_2O	3.57			Zircon	0.1
K_2O	5.23				
H_2O+	.27				
H_2O-	.06				
	100.14				
Sp. gr.	2.626				

Analyst: A. F. Buddington.

Some specimens of the granite gneiss show up to 40 per cent quartz and others show a greater percentage of hornblende. There is no evidence of any intrusive relation of the granite to the granosyenite, and it is believed to be simply a very siliceous phase of the syenite-granite complex.

Along the road, southeast of Middle Branch Settlement and south of Fish creek, there are outcrops of a coarse gneissoid granite which do not have the same appearance as the granosyenite or its granitic facies. The relations of this rock to the syenitic phases were not found, and for this reason, and because of its small extent on this sheet, it has not been mapped. It may be a contact phase of the younger porphyritic granites, or it may be only another variation of the granosyenite.

The porphyritic granosyenites of the Diana mass are younger than the other facies; it may be possible that the Croghan granosyenite is younger than the Diana mass; but all are cut by still younger dikes of hyperite. The Carrol School hornblende granosyenite is probably a younger facies of the syenite-granite complex, although it is intrusive into the medium-grained granosyenite on the east and into the augite-hypersthene band near Tinney Corners. The granite at Bisha's Mill appears to be simply a more siliceous facies of the granosyenite.

Hyperite. About two miles southwest of Jerden Falls is the northern tip of a small stock of hyperite. Dikes of hyperite are common in the surrounding rocks, and thus indicate that this is probably the youngest member of the monzo-diorite-syenite-granite complex, at least in this quadrangle.

It is a very tough rock with a conspicuous diabasic texture. In thin section it is found to consist dominantly of interlocking laths of

labradorite with granulated pyroxene filling the intervening spaces, or of massive pyroxene and labradorite in ophitic intergrowth. Most of the pyroxene is diallage, but hypersthene may also be present. A considerable portion of the pyroxene is altered to an aggregate of hornblende and brown biotite. A small portion of the feldspar is usually granulated. Olivine, with reaction or resorption rims, is also present.

The augite-hypersthene syenite near Tinney Corners is an intermediate stage between the hyperite and the normal syenite. So far as known, the hyperites are constantly associated with the syenitic rocks wherever found in the Adirondacks, and only with them. They are therefore considered to be genetically connected with the syenite-granite complex.

Dike rocks. Narrow dikes of black hyperite are common in all facies of the syenite, and rarely one is found in the Grenville gneiss immediately adjoining the northwestern border of the main batholith. Their occurrence is confined exclusively to the southeastern portion of the sheet; and this fact, together with the character of their foliation, indicates that they are genetically allied with the syenite. Where uncrushed, these dikes exhibit a massive, diabasic or ophitic texture and in thin section are found to consist of interlocking labradorite laths, with hypersthene and augite filling the interstices, or in larger grains inclosing the feldspars. A considerable proportion of the pyroxene is always in a finely granular condition, a result of primary crystallization, however, and not of secondary crushing. Microperthite is rarely present.

Other dikes occasionally present are fine-grained porphyritic hornblende syenite and augite hypersthene syenite. The latter rock consists of microperthite, oligoclase, augite, hypersthene and quartz, named in decreasing order of abundance, with accessory magnetite, apatite and rare zircon.

Dikes of granosyenite are common in the mass along the northwest border near the contacts with the Grenville. These are of a pegmatitic nature, some of them exhibiting a graphic intergrowth of quartz and feldspar and, in one dike, a violet colored tourmaline was found.

Near the southern border of the porphyritic hornblende granosyenite dikes of this rock are common in the surrounding rock.

Differentiation. The problem of primary importance in connection with the differentiation of the syenitic magma, is as to whether the various rocks are successive intrusions, direct products of assimilation of Grenville, the result of differentiation, *in situ,* or

of crystallization, *in situ,* of an already differentiated and heterogeneous magma.

The first possibility is negatived by the fact that, in general, the variants do not exhibit intrusive relations to one another. It is true that the porphyritic granosyenite intrudes the other syenites, and that numerous hyperite, granite and other dikes cut the syenites; but even these, as previously pointed out, must belong to a late stage of differentiation, preceding the complete consolidation of the igneous mass.

The banded character of the syenite might suggest that the variation did not arise through differentiation but through assimilation, more or less in place, of bands of Grenville of varying composition. Wherever such connection can be established as certain or probable, the rock has some exceptional character, such as the presence of titanite, graphite or garnet, an excessive amount of ferromagnesian minerals, an abnormally basic plagioclase, or, more rarely, cordierite, a peculiar deep green pyroxene, or other peculiarity. Unassimilated blocks are also found occasionally throughout the mass.

Along the contact of the syenite with the Grenville gneisses, northeast of Harrisville, the syenite is normally green but so frequently shows a local reddish hue adjacent to inclusions of gneiss that the suggestion arises that assimilation is the cause of the change. This change, however, is slight, for in sections the red and the green phases are the same, except for the color, and the former has not become more siliceous and more hornblendic, like the normal red hornblende syenite of the main mass, due to differentiation.

It would thus seem that variations through assimilation, while present, are a minor phenomenon, and that some process of differentiation is responsible for the larger variations of the main mass.

If we assume that differentiation went on, in place, through the influence of gravity, we are confronted with the fact that if the dip of the foliation planes indicates anything as to the top or bottom of the mass of syenite, then the more basic phases are at the top and the more siliceous phases at the bottom, the reverse of what we should expect.

Again, if we assume that the border is the result of quick cooling of a basic magma, and that the inner, more siliceous bands are the result of further differentiation, with contemporaneous movements of the magma, we are met by the facts that the basic bands are not fine grained, but are as coarse as, if not coarser than, the more siliceous bands, and that they are not confined to the border but are interbanded with the other variants.

The hypothesis that we are dealing with a mass which was intruded as an already differentiated magma, although involving serious theoretical difficulties, fits the facts of structure and distribution in the field, as now known, although future work may prove it to be inadmissible. This hypothesis explains the sharp banding of the various facies, their interbanding and such variation in the quickly chilled outlying bosses and dikes of syenite in the Grenville as is not due to contact metamorphic effects. But repeated displacements and movements of the magma at intervals while undergoing differentiation approximately in place are proposed as affording the best explanation of the phenomena and in better agreement than any other hypothesis with both the field data and our present theoretical views as to magmatic differentiation.

A final decision in regard to this important problem must await the results of work in surrounding quadrangles, not to mention the much-needed increase in our knowledge of the physico-chemical principles controlling the phenomena of magmatic differentiation. An adequate solution of the problem must doubtless be more complex than any of the simple hypotheses referred to.

Younger Granites

The term "younger granites" is used to distinguish those masses of granitic character which, from their mode of occurrence and degree of metamorphism, are believed to be younger than the dominant facies of the syenitic rocks. They include two types, which differ both in their mode of intrusion and occurrence and in their character. One of these types is the fine to medium-grained granite of the California and Clark pond batholiths and of numerous small bosses, and the other is the coarse porphyritic granite intruded, for the most part, in lenticular fashion along the foliation planes of the Grenville.

Clark pond batholith. This granite appears as an elliptical area running southeast from Lake Bonaparte. It forms a comparatively flat-topped table-land covered with a thick growth of underbrush. The rock is a trifle coarser grained than that of the California batholith and is believed to represent a deeper seated phase of the same magma.

It is not a clean cut, homogeneous mass, but exhibits locally such sharp changes of grain that intrusive relations might be suspected, although such could not definitely be found. The rock is also frequently tainted with material derived from assimilation

of Grenville inclusions. The dominant rock is a medium-grained, pink granite, which weathers light gray or reddish brown. Near the border it carries, as inclusions, long stringers of amphibolite and other Grenville fragments. Here, also, it is seamed with quartz and pegmatite veins parallel to the foliation.

In thin section the rock is found to consist of microperthite 56 per cent, quartz 40 per cent, light green to colorless augite, partially altered to hornblende, 1 to 2 per cent, ilmenite 1 to 2 per cent, and accessory zircon, apatite and titanite. The texture is granitoid, with a gneissic structure in variable degrees of development. The ferromagnesian minerals are not essential to the rock, but are due to contamination from foreign material, the rock being essentially alaskitic in nature.

California batholith. This batholith outcrops in the four towns of Fowler, Pitcairn, Diana and Antwerp. It is in process of exposure from beneath a cover of biotite-garnet gneiss, which formerly passed over it in anticlinal fashion. Adjacent to the main mass are several sills of similar granite, intruded along the foliation planes of the gneiss.

The rock is a fine to medium-grained pink granite, similar in appearance to that of the Clark Pond batholith. As in the latter batholith, so here also, the granite is locally contaminated by partial assimilation of foreign material. Long, narrow bands of black pyroxene and hornblende gneiss are also common as inclusions, particularly near the borders.

In thin section the rock is seen to be granitoid in texture, with a tendency toward a seriate intersertal fabric of gneissic pattern. It consists of quartz, varying from 30 to 45 per cent; microperthite, varying from 35 to 40 per cent; and oligoclase andesine, varying from 15 to 30 per cent. Ilmenite occurs up to 2½ per cent, and a deep green biotite up to 1½ per cent. Minute zircons are common. The amount of plagioclase increases very perceptibly toward the borders of the batholith.

Magnetite lens. A very interesting feature of this batholith is a small lens of magnetite about ½ mile southeast of Rices Corners. A prospect pit has opened up a small body of medium-grained, massive, granular magnetite for 20 feet along the strike and 30 feet along the dip. The ore thickens from an inch or so at the top to a foot in the thickest part along the dip. The strike and dip of the lens are parallel to the foliation of the granite. The ore contains a little feldspar and quartz. Where it frays out at the top, it appears to have actual intrusive relations with the granite. The granite here

possesses a higher degree of foliation than usual and in thin section exhibits a protoclastic texture in which the feldspars are considerably granulated and the quartz is in elongated lenses, wholly uncrushed. These phenomena would indicate that the magnetite is a product of magmatic differentiation, brought into its present position after a foliation had been produced in the partially crystalline granite, but before the crystallization of the quartz.

Porphyritic granite. This rock forms numerous long sheets and lenticular bodies within the Grenville gneisses. The typical rock is coarsely porphyritic, with phenocrysts of feldspar averaging from ½ to 1 inch in length, in a medium-grained groundmass of feldspar, quartz and biotite. The phenocrysts may vary up to 3 inches in length or down to a small fraction of an inch in the chilled border phases. The latter are usually finely porphyritic but, where forming dikes or small isolated masses, they become medium-grained and more or less equigranular. The rock is then indistinguishable from the granite of the California or Clark pond batholiths, unless porphyritic phases can be found. The facies of the porphyritic granites are, however, nearly always coarser and redder in hue than the Clark pond and California granite.

Dikes and small masses of the rock may be massive, but there is nearly always some appearance of foliation which is especially marked on the borders of the larger masses.

In thin section the rock is found to consist of microcline, some of it with microperthitic intergrowths, oligoclase, quartz and biotite, with accessory zircons, apatite, magnetite and ilmenite.

FOLIATION

The term "foliation," as usually understood, refers to the banding or cleavage of metamorphic rocks, but it will be used here in a somewhat broader sense, as synonymous with the term "gneissic structure" which is defined by Leith (1913, 87) as follows: "Gneissic structure means a banding of constituents, of which feldspar is important, with or without the parallel dimensional arrangement necessary for rock cleavage." This includes both the finer banding due to variations in composition or structure, and the laminated structure produced by the parallel arrangement of any or all constituents.

Gneissic structure may arise in many different ways, and specific names have been given to most of the various types. Thus, within igneous rocks, it may arise during the progress of crystallization, while the magma is still partly liquid, as a result of the crushing

and granulation of the products of early crystallization. A texture thus produced is called "protoclastic." Or, a rock may acquire a gneissic structure as a result of crushing during earth movements subsequent to its complete solidification, and the texture is then called "cataclastic." Both of these types of crushing may be recognized within the syenitic rocks of this quadrangle. There are, however, other types of foliation in igneous rocks, into the origin of which the element of crushing does not enter. Examples of foliation with the element of crushing absent may be found in much of the so-called primary flow gneiss, injection gneiss, resorption gneiss (or gneiss owing its structure to resorption of or reaction with schistose rocks), etc. Such a foliation characterizes the rock of the southeast portion of the syenitic mass and much of the younger granite. Another type of foliation is that which has arisen through recrystallization of dynamically metamorphosed rocks, which characterizes part of the Grenville gneisses.

The problem of the origin of the foliation in the Precambrian rocks of the Adirondacks, and in similar rocks in the adjoining regions of Canada, has been very much to the fore in recent years. Geologists, working each in his respective district, have arrived at sharply contrasted conclusions regarding the origin of the foliation in such districts.

The two outstanding problems in this connection are: (1) Have any or all of these rocks undergone intense lateral compression? (2) Has the foliation of the igneous rocks arisen for the most part subsequent to the complete consolidation of the rock or during the process of consolidation? In other words, is the foliation a cataclastic or a protoclastic structure?

The answer to the first question with respect to the Adirondacks has, in the past, been usually affirmative; but Miller (1916, 587–619) has recently vigorously combatted this view. Thus he says (592): "We are thus led to conclude that none of the published Adirondack geologic maps or available data afford any reason to believe that the Grenville strata were ever profoundly folded or compressed." Martin (1916), on the other hand, has conclusively proved the presence of isoclinal folding in the Canton quadrangle, on the northwest border of the Adirondacks.

With regard to the second question, there has been a growing tendency to regard much of the foliation of Precambrian batholiths as formed during the progress of consolidation. This has been advocated, among others, by Lawson (1887–88, 131), Barlow (1899, 60 *et seq.*), and Adams (1915, 74–75) in Canada, and recently by

Miller in the Adirondacks (1916, 587–619). On the other hand, Cushing, in a report on the Thousand Islands Region, says (1910, 101):

It is quite possible that much of this compression was a result of the actual intrusion, and that the granite gneiss actually solidified with a foliated structure. . . . While it can not be affirmed that such results were not brought about in the region, it can be positively stated that, if so, they have been so disguised by subsequent compressive stresses that the effects of the two can not now be successfully disentangled.

This divergence of views on the intensity of compression and the origin of the foliation in different rocks in different districts emphasizes the necessity for caution in applying any current general explanation to the rocks of this district. For this reason and because of the perplexing variation found in the metamorphic character of the rocks themselves, a rather detailed study was made of this problem. A series of 400 slides, in part chosen haphazard and in part carefully selected, were examined with respect to the character of the metamorphism which they showed.

Some conclusions have been reached, which are believed to be valid for this district; but it should be distinctly understood that these conclusions are based solely on a study of the characters of the rocks of this area, and hence refer to the character of the metamorphism within this area only.

These conclusions are summarized in the following pages, the detailed descriptions being given later.

Summary of Foliation of Various Rocks

Foliation of Gabbro. The gabbro occurs in narrow sheets and small bosses in the limestones and, although the oldest igneous rock of this district, yet has been almost wholly protected by them from crushing. The foliation of the mass near Geer's Corners is a narrow banding, originating through mineral segregation during crystallization. The foliation of the remainder of the gabbro is due to the dimensional orientation of the component minerals and is likewise independent of crushing or recrystallization, perhaps arising during the primary crystallization from the molten magma. Only locally is the gabbro crushed.

Foliation of syenite-granite complex. 1 When the syenitic gneisses are grouped according to the characters of their textures, it is found that they fall into three distinct belts: (*a*) a belt on the southeast in which there is no sign of crushing and in which the

texture is similar to that resulting from the normal crystallization of a magma (plates 3 and 4); (*b*) a central belt in which the quartz is in massive leaves, whereas most of the other minerals are granulated (plates 5 and 6); and (*c*) a belt on the northwest in which the quartz is granulated, whereas most of the other minerals are pulverized (plates 7 and 8); or three belts in which the textures from southeast to northwest are respectively: one of normal crystallization from a magma, a protoclastic texture and a cataclastic-protoclastic texture.

2 Foliation and banding are always parallel.

3 The degree of crushing is for the most part independent of the chemical or mineral composition (plates 5, 6, 7 and 8).

4 The uncrushed gneiss is equigranular (plates 3 and 4); the crushed gneisses are porphyritic or lenticular in texture (plates 5, 6, 7 and 8).

5 The foliation is for the most part independent of the degree of granulation or crushing (plates 3, 5, and 6; 4 and 7), but may be slightly accentuated by crushing.

6 Quartz and magnetite—where they were the last to crystallize—are less crushed than the other minerals (plates 5, 6, 7 and 8, lower figure).

7 The degree of crushing of the quartz is roughly proportional to the degree of crushing of the other minerals.

8 The primary foliation of the southeast belt is due to mineral segregation into streaks and to dimensional orientation of the minerals by crystallization under stress, or to rotation by flowage in the magma, and is not accompanied by crushing. The foliation of inclusions at an angle to that of the enclosing rock, a texture and succession of crystallization normal to igneous rocks, occasional euhedral character of the minerals, the segregation of apatite, zircon and magnetite with the ferromagnesian minerals, the presence of feldspars showing zonal growth, the absence of uralite and of secondary hornblende or biotite, and the presence of massive hyperite dikes at an angle to the foliation of the country rock, seem to preclude an explanation of this foliation by recrystallization.

9 The protoclastic nature of the foliation of the central belt is evidenced by the following data: the granulated character of the feldspars and ferromagnesian minerals and the normally uncrushed character of the quartz, the parallelism of the foliation and banding irrespective of widely divergent orientations, and the orientation of slender, unbroken zircon crystals with good crystal faces

10 The evidence of a pre-existing protoclastic foliation in the cataclastic gneiss of the northwest belt is: the presence of a gradual transition into the protoclastic gneiss of the central belt, through a disappearance of the superimposed cataclastic features, and the presence of characters similar to those of the latter belt.

11 The grains resulting from the crushing of any rock within the central belt, with only rare exceptions, average over 0.1 mm in diameter, those of the northwest belt (quartz excluded), under 0.1 mm in diameter, but the proportion of the minerals in the rock of both belts which is reduced to these respective sizes is very variable in different bands, often sharply delimited, and parallel to the foliation.

12 The secondary progressive crushing took place, in part, subsequent to the intrusion of the youngest facies of the syenite-granite complex, and is only in part due to a shouldering influence exerted during the process of intrusion, because

a Later intrusive dikes of hornblende syenite, hypersthene syenite, hyperite, and granosyenite show the same degree of crushing as their country rock (plates 9, 10 and 11). The hyperite dikes cut all facies of the syenite-granite complex, and are presumably of the same epoch.

b In many cases, in each of the three belts of metamorphism, dikes have been observed which are crossed by the foliation of their enclosing country rock.

13 Intense compressive forces in a northwest-southeast direction were active throughout the process of intrusion and consolidation, and were renewed or continued subsequent to the complete solidification of at least part of the syenite-granite complex; thus

a At the beginning of intrusion, as shown by the elongated, lenticular character assumed by the different magmatic portions while still in a fluid or partially fluid state, and by the primary foliation, independent of crushing, of the southeast belt, and partial primary origin of the foliation of the other belts.

b At a late stage in the progress of crystallization, as shown by the protoclastic structure of the central belt, and previous protoclastic structure of the northwest belt.

c Subsequent to the complete consolidation of the entire mass, as shown by the superimposed cataclastic structure of the northwest belt.

Foliation of granites. 1 The granite batholiths show no metamorphism equivalent to the more mashed phases of the syenite-granite complex. They often show intrusive relations to the syenite and hence are younger.

2 The foliation originated exclusively during the progress of crystallization of the magma. It is in part of protoclastic origin, but dominantly independent of crushing, as shown by the following facts:

a Either slight or no effects of crushing are usually visible (plates 12 and 13), and what there are are usually confined to the feldspars (plate 14).

b The intruding rock, whether granite or its associated pegmatite, may show greater dimensional elongation of quartz and more crushing of the feldspars than the intruded gneiss.

c The foliation is parallel to the borders of the batholith, irrespective of the direction of the latter.

d The foliation is, in places, almost horizontal.

e In many of the granite masses the genetically associated pegmatite veins are conspicuously parallel to the foliation along the borders of the mass.

f The foliation of the gneiss in the California batholith exhibits in some places a puckered character parallel to the borders of crumpled inclusions, or shows flowage lines around inclusions.

3 The direction of foliation has been influenced, to a very considerable extent, by the shouldering aside of the country rock by the magma; but the lineal elongation of the batholiths during their intrusion was controlled by a northwest-southeast force, perhaps of only moderate intensity.

Foliation of mixed rocks. The foliation of these rocks has had an exceedingly diverse and complex history. They now include relic and resorption or reaction gneisses, injection gneisses and pegmatitized and recrystallized gneisses.

The major elements of the foliation are believed to have been an earlier foliation in the Grenville gneisses, of unknown origin; the local injection of syenitic material into the Grenville parallel to the foliation; a cataclastic texture formed by the widespread granulation of the Grenville and intruded syenites by intense lateral compressive forces; and a subsequent igneous metamorphism involving injection of granitic pegmatite veins along the foliation planes of the Grenville; shredding, disintegration and reconstruction of the Grenville by both pegmatites and granites; pegmatitization, recrystallization and contact metamorphism. Where not recrystallized by igneous metamorphism, connected with the intrusion and injection of the younger granites and their pegmatites, or protected and preserved by the easily recrystallizing, plastic limestones, the gneisses locally exhibit a cataclastic texture. Where recrystallized, the Grenville

gneisses show the textures of contact metamorphism, and the dimensional elongation and orientation of minerals characteristic of intense pressures.

Palimpsest textures, in which the minerals of the pegmatite veins are oriented at an angle to the biotite of the Grenville portion, preclude the explanation of the foliation solely as a result of dynamic metamorphism with contemporaneous recrystallization, as does likewise the difference in grain and texture between the Grenville portion and the injected pegmatite and locally between the Grenville and intruded syenite sills, the latter showing a greater degree of granulation of the feldspars.

Details of Foliation of Various Rocks

Foliation of gabbro. The gabbros within this quadrangle have been intruded, almost exclusively as narrow sheets, into the limestones. For this reason they were preserved from the intense crushing which some of the younger syenitic masses suffered, and retain for the most part their original texture. The rocks usually exhibit a moderately developed gneissic structure but vary from massive to conspicuously gneissoid. The texture of the massive phases is allotriomorphic, and the finer grained facies have a granulitic appearance. This is not surprising since masses of syenite like those which elsewhere are mashed are here similarly protected from crushing by the limestones which have taken up the strain. In rare sections slight cataclastic effects are apparent, all the minerals are crushed and the residual feldspars exhibit strain shadows. Thin gabbro sills in limestone, about ½ mile southwest of Geers Corners, are in a very intensely crushed and pulverized condition. This is a local phenomenon, however, for the foliation of the gabbro appears to be for the most part an original texture.

A previous description by the senior author of the peculiar banding of the gabbro mass east of Geers Corners is repeated here.

The most pronounced feature of the gabbro as seen in the field is the great variation from point to point in composition and structure. On the one hand, the constituents may be less than a millimeter in diameter, while on the other, they may reach an inch or more in their greatest dimension. Naturally the finer portions are more conspicuous near the margin, but there are abundant exceptions to the rule. In composition there is a range from a nearly black rock, composed almost wholly of ferromagnesian minerals, to a rock consisting chiefly of white feldspar with a few prismatic pyroxenes. The latter is the least abundant variety, the bulk of the rock being dark-colored. It is surprising how many varieties of the gabbro may

appear in a small area, the passage between the most extreme phases often taking place within 5 or 6 feet. Such variations are of course, very common in basic igneous rocks, but it is probable that there is nowhere a more striking example of the phenomenon.

The banding (plate 1) is a primary phenomenon and may be connected in some way, not now understood, with the numerous sheets of limestone, as the gabbro masses elsewhere do not show it.

In the other gabbros there are always slight traces of crushing, but the feldspars are dominantly free of strain shadows and interlock, after the manner normal to crystallization from an igneous magma. The biotite scales also may finger into the inclosing feldspars, and some are more or less equidimensional. If the present texture were due to recrystallization, all these biotites should be more elongated and the augite more altered to hornblende.

Foliation of granite-syenite complex. *Primary foliation of southeast belt.* The foliation of the rocks in this belt is entirely independent of any crushing, either of protoclastic or cataclastic origin. It is also independent of the character of the rock; for hornblende syenite, hornblende-biotite granosyenite and biotite granite, all show similar phenomena of foliation without crushing. The dip of the foliation is prevailingly steep, varying between 60° and 80°.

The foliation of the hornblende syenite, grano-syenites and granite gneisses is mainly due to a process of segregation whereby the ferromagnesian minerals, chiefly hornblende with subsidiary biotite, have been collected together into lineal aggregates or thin lenticular sheets; the feldspars, with a little poikilitic and interstitial quartz, into similar thicker sheets; and the quartz into more or less smeared out, elongated lenses which accommodate themselves to the minerals of the adjoining sheets; all three being parallel. The foliation is due in a less degree to a dimensional orientation of the ferromagnesian minerals arranged through flowage and to dimensional orientation of feldspars, due partly to flowage and partly to actual crystallization, with dimensional orientation, under differential stresses. With a decrease in the amount of ferromagnesian minerals and an increase in quartz, the foliation depends to a greater extent on the elongated, lenticular character of the quartzes. In one exceptional instance there is an added type of foliation superimposed upon that just described, which links it with the type to be discussed, namely, a granulation of the minerals along thin sheets—a protoclastic structure.

As seen in the field, the foliation often shows a cross crenulation

or crumpling, of slight amplitude, at right angles to the prevailing trend, giving the rock a wavy appearance.

That the foliation of these rocks is not a result of dynamic flow or of recrystallization subsequent to mashing, is indicated by the following facts: The succession of crystallization of the constituent minerals is in the order normal for igneous rocks, namely, apatite, zircon and magnetite; hornblende and biotite; plagioclase and microperthite; and quartz; with some overlapping. Secondary reactions characteristic of magmatic crystallization are common, such as the reaction of the magma with hornblende, biotite and feldspar, and the crystallization of later minerals in the rounded embayments. The feldspars show an interlocking growth normal to primary crystallization from a magma. Although straight lineal contacts do occur between some grains in these rocks, they are nevertheless peculiarly characteristic of the granulated rocks next to be described. Euhedral crystals of hornblende may occasionally be found, and elongated areas of quartz occur oriented at any angle to the foliation. Exceptionally, the lines of foliation are involved in complicated curves typical of a primary flowage structure. The growth, in place, of dimensionally oriented crystals is indicated by the phenomena of feldspar grains oriented parallel to the foliation, and inclosing, entirely or partially, similarly oriented crystals of zircon and biotite. Some of these inclosed grains, however, are not oriented parallel to the foliation, indicating perhaps a rotation of the inclosing crystals into dimensional parallelism to planes of flowage. This growth of crystals under conditions of unequal strain, with dimensional parallelism, has been experimentally demonstrated by Wright (1906, 226).[1] Again, near Jerden Falls, there are abundant inclusions of Grenville gneiss, whose foliation is oriented at an angle to that of the inclosing rock. Furthermore, the presence of massive hyperite dikes, known to be older than the foliation, yet cutting across the gneissic structure of the country rock, can not be explained by a theory of recrystallization. Finally, there is a tendency for the minerals of early magmatic crystallization, such as magnetite, apatite and zircon, to be concentrated within the streaks formed of ferromagnesian minerals.

Plates 3 and 4 illustrate well-foliated rocks of different compositions but with normal crystallization textures, showing that foliation

[1] Since this was written, Feild and Royster (1918) have shown that certain molten silicate mixtures exhibit a definite rigidity at low shears, (Temperature-Viscosity Relations in the Ternary System $CaO–Al_2O_3–SiO_2$, Technical Paper No. 189, Bureau of Mines). It would therefore seem probable that conditions suitable for unequal strain may be present in a crystallizing magma.

need not in any way be dependent upon the degree, or even the presence, of crushing.

For comparison a photograph and photomicrograph (plate 2) of a thoroughly massive augite syenite are shown. This rock is a quickly chilled contact phase of the augite syenite, from northeast of Harrisville, which has been preserved from crushing by the cushioning effect of the adjacent Grenville.

A very interesting phenomenon is the frequent tendency toward the development of incipient cracks in the magma along which a more felsic variant develops. Such a crack is shown in the upper figure of plate 3, crossing from the upper righthand corner to the lower left. The felsic phase may be of the same grain as, or slightly coarser than, that of the main rock. In the latter case it has a pegmatitic appearance and is massive in character, for the most part cutting directly across the gneissic structure. In all such cases the contacts are blended. To a less extent a coarser grain is developed along ramifying ghostlike veinlets, in which case many of the hornblende streaks are undisturbed and pass uninterruptedly through the veinlets. In rare instances ferromagnesian minerals have been concentrated along such a crack, as in the black streak which crosses at right angles to the gneissic structure in the lower righthand corner of the upper figure of plate 4. Differential movements of the magmatic layers are also well shown in many cases. In the center of the upper figure of plate 3, there is a mass of felsic minerals which has broken across several hornblende streaks, and has pushed another one ahead of it until it joined the next adjacent hornblende lineal, the magma which originally separated the two hornblende streaks having been squeezed out on either side.

Protoclastic foliation of central belt. Within a belt about 2 to 2½ miles wide, comprising the central portion of the syenite-granite complex, all the minerals except quartz are more or less granulated. Since the discrimination of the minuter details of the character of the foliation of the rocks can be determined by means of the microscope only, data are not at hand to either assert or deny a gradual transition between the granulated character of the minerals observed in this belt and the wholly uncrushed character of the minerals in the rock of the belt to the southeast. The most that can be said is that if such a transition occurs, it must be relatively sharp, since in one case in thin sections of rocks but 200 yards apart the structure of one is that of crystallization normal for the southeast belt, while the structure of the other is that of granulation common to the rocks of the central band. The dip of the foliation is

usually steep, varying from 45° to 70°, and prevailingly northwest.

The structure of the rock as seen in thin section is a granular groundmass with elongate, uncrushed quartz lenses (plate 5, B), and phenocrysts of feldspar, augite or hornblende, with trails of granulated material leading away from them, or with a "mortar" of such material surrounding them or traversing them in veinlets. The granules of crushed material usually have straight lineal borders and are frequently roughly hexagonal or pentagonal in shape. They are dominantly equidimensional, averaging from 1 to 3 mm, with a very variable grain in parallel sheets. Where not equidimensional, they are oriented parallel to the foliation. The quartz is very rarely granulated. In only two of the many thin sections of rocks from this band was any granulated quartz found. In these sections angular grains of quartz are distributed among the other granules; but there are in addition larger areas of clear, uncrushed quartz. On the other hand, in one thin section a single leaf of quartz, which extinguishes simultaneously, is 12 times as long as wide. In the same section there are five of these quartz leaves, the average ratio of whose length to breadth is 9 to 1. Zircons, in long slender rods, are usually oriented parallel to the foliation, and are far more often whole than broken. Apatite is usually granulated and drawn out into long trails. It is commonly associated with magnetite, and there is a frequent tendency for magnetite to crystallize in fractures of the apatite. Magnetite of early crystallization, like the apatite, is crushed and strewn out in long trails. There is, thus, magnetite of two ages in these rocks. The early magnetite was among the first products of crystallization, is often inclosed in other minerals and has suffered granulation; the later magnetite, found only in small segregations, was the last mineral to crystallize out, is molded on the other grains and is uncrushed or only slightly granulated. It is peculiar that the granulated hornblende is predominantly associated with quartz, occurring on the borders of the quartz leaves. It does, however, occur in streaks within feldspar aggregates.

In much of the rock the large feldspars are crushed and reduced to lenticular aggregates of granules, giving the rock a lenticular texture (plate 5, upper figure). Occasionally only the borders of the feldspars are granulated, leaving residual, lenticular, uncrushed cores. With a greater degree of crushing, the elongation of the lenticular granular aggregates may increase until the rock presents a streaked, equigranular appearance, with only a few residual, uncrushed, lenticular cores (plate 6, upper figure). The size to which the grains are crushed need not be much finer, in such a rock, than in the previous

type. In superficial appearance such a rock begins to resemble that of the southeastern belt, although having a different history. The rock did possess, however, an original foliation which was independent of crushing or recrystallization. This is indicated by the common occurrence of uncrushed, elongated lenses of quartz, by the dimensional orientation of the uncrushed plagioclase cores of the residual phenocrysts, and by the alignment and concentration in streaks, of the residual cores of hornblende crystals.

As in the preceding belt, the physical character of the foliation is here largely independent of the chemical or mineral composition of the rock. Granosyenite, hornblende syenite, augite syenite and augite-hypersthene syenite, all show similar foliation, with similar internal, partly granular, structure, and elongated, uncrushed quartz lenses in greater or less abundance, dependent upon the composition of the rock.

Protoclastic nature of foliation. There is a rather uniform agreement among geologists that, under conditions of strain and crushing of a crystallized rock, quartz is the first mineral to suffer. The association of uncrushed quartz with granulated feldspar is susceptible of explanation as a result either of recrystallization of the quartz from a crushed condition, of plastic molecular flow under stress, or of its crystallization from a fluid state in a partly solidified magma, after the cessation of stresses which granulated the feldspar. While in the present case the evidence is not conclusive for a decision between these alternative explanations, the latter seems much more probable. Thus the elongation of the quartz lenses is often only slightly, if any, greater than it is in the wholly uncrushed gneiss on the southeast, so that it is unnecessary to assume a previous crushing to explain this character. The character of the structure is in every way similar to that of the borders of the younger granite masses, which it is confidently believed have had a protoclastic origin. The last minerals to crystallize are the least crushed, namely, all the quartz and that small part of the magnetite which crystallized out last.

Cataclastic-protoclastic foliation of northwest belt. The rest of the syenite—some dikes in the Grenville series and local contact phases alone excepted—now presents the appearance of a foliation, ranging in dip from 30° to 80° with an average of 45° northwest wholly of cataclastic origin. It is certain, however, that it represents a palimpsest, or the superposition of cataclastic features upon a previous protoclastic structure, which in turn had modified and accentuated a foliation wholly of primary origin, like that of the southeast

belt. Between the rock of this belt and that of the belt with protoclastic foliation on the southeast, there is a progressive transition, although the boundary line between them can still be quite sharply drawn. On approaching the boundary from the southeast, the degree of granulation of all the minerals, except quartz, very rapidly becomes more intense until they are so finely crushed as to be quite accurately described by the term "pulverized." Similarly, the quartz near the border begins first to show an increasing number of fractures in the long lenses until it takes on a granular character, becoming progressively finer towards the northwest, and is finally pulverized. The division line between the gneiss with protoclastic foliation and that with the superimposed cataclastic features was drawn where the quartz first assumes a granular character and the other minerals are pulverized, with an average diameter of grain of 0.1 mm or less. It is significant that the boundary line between rocks with these different dynamo-metamorphic characters is independent of the rock boundaries based on composition.

Phenocrysts usually are in parallel alignment, as a result of primary flowage in the magma, and not as the result of rotation during crushing (plate 9, upper figure).

The degree of crushing and average diameter of grain are exceedingly variable, when viewed in thin section, sheets of coarse and fine material forming alternating thin lenticular sheets, with grain varying from .01 to .15 mm. The quartz grains average from 2 to 5 times as large as the feldspar grains.

The feldspars, pyroxenes and hornblendes are partly or completely pulverized, peripherally crushed and worn by attrition, or sliced and traversed by veinlets of crushed material. The quartz forms elongated lenses, thin, anastomosing, bifurcating veinlets or sheets, or networks, inclosing the other minerals. It is always less crushed than the other minerals, usually possesses a granular character, but is locally pulverized. It is prevailingly more crushed on the outer borders of its masses than at the center. Indeed, in exceptional cases, uncrushed but highly strained areas of quartz may occur at the core of such lenses. Quartz rarely occurs in small grains, mingled with the groundmass, but is invariably segregated in lenses. Slender rods of zircon are often oriented, unbroken, parallel to the foliation, while magnetite of early crystallization and apatite grains are mashed. Wedges of crushed material frequently develop inward from the margins of the feldspars, without completely traversing them, terminating in strained zones.

Granosyenite, hornblende syenite, augite syenite and basic augite

syenite, all exhibit similar intense degrees of pulverization independent of their chemical or mineral composition. Some dikes in the Grenville limestone, and local masses of the syenite at contact with the Grenville, however, are massive or only slightly crushed, as a result of the cushioning effect of the limestone.

Except for the finer degree of crushing, or pulverization, of all the minerals but quartz, and the granulation or local pulverization of the latter, the character of the foliation is similar to that described in the preceding section. Bands in which the rock is composed dominantly of phenocrysts are interbanded with those in which they are moderately abundant or scarce. The contact between two such streaks, or bands, may be sharp and confined to a width of a millimeter. It is hard to say how much this variation in texture is primary and how much the result of secondary crushing. That the primary character may be a factor is indicated by the primary sharp composition variations and the usual high proportion of phenocrysts in the more basic phases; whereas the great importance of the secondary factor is indicated by actual drawing out of the phenocrysts into narrow bands or streaks, and the observed occurrence of uncrushed phenocrysts in the midst of completely mashed material.

Evidence of previous foliation. The rock of this belt must originally have possessed a foliation similar to that of the adjoining rock on the southeast, namely, a protoclastic foliation, since the quartz within this mass is not crushed sufficiently to account for its great elongation. Moreover, the actual transition into a rock with a protoclastic structure, only, through a decrease in the degree of crushing shows, that the cataclastic structure of this band is a superimposed phenomenon. The further fact that the boundary of this secondary mashing is independent of the composition banding of the rocks and hence of the foliation, also is conclusive evidence of the previous existence of a foliation. This is further accentuated by phenomena connected with the zircons. Many of these, with good crystal faces, are oriented parallel to the foliation. If this orientation had not been a primary phenomenon, many more of these crystals should have been broken during rotation. Again, Trueman states with reference to recrystallization during dynamic metamorphism (1912, 251) that "zircon is remarkably stable under the conditions present during the development of foliation." This would indicate, then, that their orientation could not be due to recrystallization, for in that case the feldspars should also be recrystallized. Moreover, if the foliation were a product of a previous recrystallization under dynamic metamorphism, the augites should have been

altered to hornblende, the normal mineral for such conditions. Again, the common segregation of apatite, zircon, and magnetite with the ferromagnesian minerals, indicates the previous existence of a primary foliation due to mineral segregation.

Hence we must conclude that the dominant element in the gneissic structure of these rocks is a primary foliation, with a cataclastic texture superimposed upon it, the latter of minor importance so far as the actual foliation is concerned, but important as indicating the continuance of intense orogenic forces after the complete consolidation of the rock.

Carrol school granosyenite. The gneissic appearance of the granite of this mass, in the field, is due largely to the orientation of the ferromagnesian minerals.

In thin section narrow bands of slightly coarser and finer grain are seen to alternate, the coarser bands dominantly showing only the normal results of crystallization; the finer grained bands, on the other hand, being composed of granular material of protoclastic origin. There are no effects of cataclastic action, or strain shadows, visible. In the coarser bands the hornblende crystals are euhedral and dimensionally oriented, and the feldspars often interlocked with sawtooth edges or are frequently bordered by zonal growths.

The granite is injected with abundant pegmatite veins which are prevailingly parallel to the foliation. These pegmatite veins occur almost wholly within the granite or the immediately adjacent rock, and hence are probably genetically connected with the former. The parallelism of the veins and the foliation indicates that the latter was formed before the completion of crystallization of the magma, while the microscopic features indicate that it was formed during the progress of crystallization and is dominantly of primary origin, with some protoclastic texture.

Foliation of dikes. The phenomena connected with the foliation of the various dikes in the syenitic rocks are of great importance in arriving at an understanding of the whole problem of the metamorphism of these rocks. All of these dikes are genetically connected with the syenitic rocks, and the important feature which they show is that the character of the metamorphism of the dikes within the three metamorphic belts is always similar to the character of metamorphism of the country rocks within these belts.

Thus the augite-hypersthene syenite mass near Tinney Corners, within the mass of rock exhibiting foliation with a primary massive texture, likewise shows but slight traces of metamorphism. Similarly the abundant hyperite dikes in the granosyenite of this district show

only slight or no traces of crushing, and the labradorite laths interlock in the normal diabasic texture (plate 10, upper figure). The slight crushing they exhibit is probably the result of the same forces which were operating to produce the primary foliation in the granosyenite.

Near the southern border of the map, in the central part of the band of syenite showing protoclastic structure, is a dike of augite-hypersthene syenite similar to the rock of the mass near Tinney Corners. But here the rock is granulated exactly like the hornblende syenite in which it is intrusive. Another dike of this material, near the intersection of the boundary lines of Fine, Diana and Pitcairn, likewise shows a granular structure similar to the inclosing rock. Several sheets of granosyenite, possibly intrusive, occur in the hornblende syenite division. These likewise show a granular structure like that of the belt in which they occur (plate II).

Near the railroad station at Natural Bridge there is a dike of augite-hypersthene syenite in the augite syenite, which cuts directly across the foliation of the intruded rock. In thin section this dike rock itself seems to be partially pulverized, like the rock into which it is intruded. A hornblende syenite dike cuts across the foliation of the syenite at a slight angle at the falls of Indian river at Natural Bridge. The foliation of the dike and of the intruded rock is, however, parallel, and both rocks exhibit the partly pulverized character typical of this band. Again, hyperite dikes are common in all types of syenite—ranging from the granosyenite to basic syenite — in this metamorphic band and invariably show a partial, to almost complete, pulverization of their minerals (plate 10, lower figure), in contrast to the similar dikes near Tinney Corners. On the other hand, a dike of similar hyperite in the Grenville limestone at Natural Bridge is quite massive (plate 9, lower figure), having been preserved from mashing by the cushioning effect of the easily recrystallizing limestone, Granosyenite dikes have been seen in all types of the syenite. These likewise show a partial pulverization of their component minerals and a granulation of the quartz. In several cases the foliation of these dikes has been observed to be parallel to that of the inclosing rock. In one instance, at a locality about 2 miles east of North Croghan, a narrow sill of granosyenite is intrusive into Grenville gneiss. For some distance it is parallel to the foliation of the gneiss, then it breaks across the rock for some distance at a large angle to again resume its parallel position. The sill where it breaks across the bedding retains a perfect foliation parallel to that of the gneiss, and hence at a large angle to its walls.

Summary. The correspondence between the degree of crushing of the dikes and the intruded rock, the occasional foliation of dikes parallel to that of the country rock, and the massive character of the dikes, where preserved from stresses by yielding limestone, are positive evidence that, in part at least, the foliation of these dikes, and hence of the whole syenite-granite complex, was controlled by forces acting from without, and not by shouldering influences resulting from the process of intrusion of the magma itself.

The character of the foliation of the rocks of the southeast belt has been ascribed to a primary origin independent of crushing or recrystallization; of the central belt, in part, to a similar origin and, in part, to a protoclastic structure; and of the northwest belt, to a cataclastic structure superimposed upon a structure like that of the central belt. That the origin of the first type has no connection either with crushing or recrystallization seems probable, and that the third type has arisen through stresses acting on a rock with characters like the second type and subsequent to its complete consolidation, there can be little doubt; but the evidence that the second type is wholly of protoclastic origin is not so positive, although it is so considered here.

The conclusion that the foliation has been governed by external compressive forces; the fact that the foliation of some dikes in the northwest portion is parallel to that of the country rock, and that the crushing of dike and country rock is variable, but similar in degree; and the hypothesis that the character of the foliation of the country rock is in any large degree of protoclastic origin seem at first thought incompatible, and such may prove to be the case. But, in spite of serious difficulties, this hypothesis seems to have the weight of evidence in its favor and is therefore tentatively adopted.

The parallelism of foliation and the similar degree of crushing of dikes and country rocks indicate that the character of both were controlled by similar forces. The present degree of crushing, or wholly uncrushed character, of much of the quartz will not permit, however, the hypothesis of mashing of the rocks when in a solid state, unless we assume a preceding cycle of crushing with recrystallization of the quartz. Evidence has already been presented against the probability of such an explanation. If we do not assume this, the metamorphic or crush structures must be considered to have been induced in these rocks to a very considerable extent after the intrusion of all the dikes; and the latter must be considered to have been intruded before the complete crystallization of the main mass or at least before

the complete crystallization of the more quartzose phases. Since these dikes show by their mineral character that they are genetically allied with the syenites, this is not such a radical or unwarrantable assumption as it would be if the dikes had no connection with the syenitic rocks. Moreover, the parallelism of the foliation and banding, where following sharp curves, points toward the origin of the foliation while the rock was still in a partly liquid state, as otherwise the foliation should cross the banding at these places.

Foliation of Granite. *Clark pond batholith.* The foliation of this batholith is indistinct in the central portion, and not well marked on the borders, except locally where abundant inclusions have been shredded away from the inclosing rock. The dip of the foliation is prevailingly steep.

In thin section the rock shows a poor to moderately developed, gneissic structure, due mainly to elongated, lobate areas of quartz and in less degree to a segregation of ilmenite and ferro-magnesian grains, and the dimensional orientation of a few microperthite crystals. The foliation is entirely of primary origin, independent of crushing or recrystallization. Most of the quartz is, however, in a highly strained condition, although not actually crushed.

The foliation of the granite at the northern end swings around parallel to its border and parallel to the foliation of the abundant group of inclusions which it enmeshes.

Locally, along the border of the mass, the adjoining gneiss has been minutely shredded by the granite which has recrystallized the inclosed material, producing a foliation inherited from the preexisting foliation of the gneiss (plate 12, upper figure).

Pegmatite veins, dominantly parallel to the foliation of the mass, are locally abundant along the border.

Foliation of California batholith. Some features which the foliation of this batholith exhibits are well adapted to show the dominantly primary origin of its gneissic structure.

Thus the foliation at the northern end of the batholith swings around in parallelism to its border and to the bedding of the overlying, adjoining, sedimentary gneisses. This would hardly be expected if the foliation were due to crushing induced by compressive forces acting from without. Not only, however, does the strike of the foliation thus box the compass, but the dip along the southeastern border of both the northern and southern masses changes, in a very short distance, along a line at right angles to the strike, from 30° northwest to vertical or steep west. The mode of this change can be inferred from actual observations that the curvature of the foliation

changes upwards, along the dip, from steep west to 50° or 60° east; and hence, presumably, if it could be followed along its former extension, it would be found to continue curving until the dip of 30° northwest was assumed, thus forming an asymmetrical anticlinal curve. As may be seen on the map, however, this dip of 30° northwest is the prevalent one and is present to within a short distance of the southeast border, in both masses. A synclinal basin of limestone and gneiss rests on the surface of the granite, separating the ends of the two masses. The foliation of the granite is parallel, both in dip and strike, to these beds wherever the contact is visible. Repeatedly, small puckers were observed in the foliation of the gneiss parallel to the surface of crumpled inclusions of Grenville. At the locality illustrated by plate 24, upper figure, the foliation of the granite can be traced flowing into the bands which cross the inclusion. Again, the foliation of the sill at Kellog Corners is parallel to the bedding of the gneisses into which it is intrusive, although it is oriented at right angles to the prevailing trend of the foliation. Pegmatite veins are often injected parallel to the foliation along the borders. All these phenomena indicate, even without the confirmation obtained by a study of the internal structure, that the foliation is not one induced by forces acting on a solid rock.

In thin section (plate 12, lower figure) the gneissic structure is seen to be due largely to elongate, lobate areas of quartz which may be of amoeboid shape or oriented at large angles to the prevailing foliation. Locally a protoclastic structure is well developed, but in no section can any evidence be found of cataclastic effects.

An additional emphasis is given to the foliation, locally, around the borders and occasionally within the batholith, by the incorporation of amphibolitic or gneissic material which it has shredded from the adjoining rocks. A more or less complete reaction and recrystallization results in a dirty looking rock, with thin alternating bands of darker and lighter material. The inclusions of narrow sheets of the rock result in a banded character of a larger scale. These rocks correspond to one type of the mixed rocks, or migmatites, described by Sederholm, representing an inherited gneissic structure or resorption gneisses.

Foliation of porphyritic granites. The foliation in these rocks, as in the fine-grained granites, is primary, exhibiting in part a massive texture and in part a protoclastic origin but no strain effects and generally no crushing of quartz. The foliated appearance in the more massive phases (plate 13) of the rock is due for the most part to the dimensional orientation of the large phenocrysts of feldspar

and to a less extent to a rude alignment of most of the biotite. The abundant dikes of granite in the Grenville beds of the northwest corner are often quite massive in character, both on the large scale in the field and in thin section. The boundaries of the grains, as seen in thin section may in one case be wholly due to normal crystallization and in another case partly due to crystallization and partly due to granulation, or wholly due to granulation and to subsequent crystallization of the quartz in the elongated interspaces. In the field the cores of the larger masses of granite show the least effects of crushing. The borders are finer grained and show to a conspicuous degree a more extensive granulation of the feldspars, elongation of the quartz and accentuated foliation. Such is conspicuously the case on the western border of the mass, northwest of Geers Corners. For a width of about ⅛ mile along this border, the rock is medium grained with a trace of finely porphyritic texture and an exceedingly elongated network of quartz which stands out in relief on the weathered surface and gives a conspicuous ribbed appearance to the rock. A single flat, lenticular quartz sheet, averaging 1mm in width, may be 20 or 30 times as long as it is wide, both along the strike and along the dip. In thin section (plate 14, lower figure) this rock exhibits a dominantly granulated structure in the feldspars, but almost wholly uncrushed quartz. A few angular grains of quartz, much smaller than the feldspars, are, however, mingled with them. The phenocrysts may be traversed, or partially traversed, by bands or wedges of granular material.

Going toward the core of the mass, the phenocrysts become larger with granular material stretching away from them and a still prominent foliation until at the core the phenocrysts assume their crystal form and the internal texture is that of normal crystallization.

As bearing on the theory of a protoclastic origin of the foliation in some of these rocks, the following observations may be relevant: A hand specimen, showing the actual contact between the granite and Fowler gneiss, was obtained at the border of the granite mass, east of Shantyville School. In thin sections of each rock adjacent to the line of contact, it was found that the texture of the gneiss was wholly that of recrystallization without crushing, whereas the granite showed almost complete granulation of the feldspars but elongated lenses of uncrushed quartz. The explanation that the granite was in a still partly liquid condition when the crushing took place seems the only one available. Furthermore, the foliation in a considerable

proportion of the central part of this mass departs but little from the horizontal.

Foliation of mixed rocks. The present foliation of the mixed rocks is for the most part a phenomenon connected with the various phases of the processes of intrusion and injection of granitic and syenitic magmas into Grenville gneiss. The foliation has had so exceedingly diverse and complex an origin that any general statement concerning it is apt to contain a considerable element of error. Hence the following discussion must be regarded as rather in the nature of a first approximation.

The dominant elements entering into the history of these gneisses are as follows: An early foliation, of doubtful origin, in the Grenville gneisses; injection of pegmatite veins, pegmatitization, recrystallization, and resorption. For convenience in systematic discussion, the gneisses have been divided into groups according to the dominant process which is believed to have entered into the formation of the present foliation of each. These groups are: pegmatitized (permeated more or less uniformly with pegmatitic material) and recrystallized gneisses, injection gneisses, and resorption (reaction) or relic gneisses. This grouping is, however, inexact, since all the processes named above enter into the formation of the foliation of each of the groups, in varying degree. The phenomena as a whole are the result of igneous metamorphism on a regional scale.

A striking likeness has been found between the phenomena connected with the foliation of the younger granites and the Grenville gneisses, and those described by Weinschenk from the Alps and by Sederholm from Finland.

Thus we have the Clark pond granite batholith completely surrounded by a contact shell of partly pegmatitized, recrystallized gneiss; the California batholith with its encasing belt of pegmatitic relic gneiss; and the Edwards mass with its core of granite resorption gneiss surrounded by a belt of pegmatitic resorption and relic gneiss; in each of which, the theories of piezo-crystallization may be applied to the foliation of the granitic portion and that of piezo-contact metamorphism to that of the surrounding gneiss.

So, also, we have the phenomena described by Sederholm (1907), such as granitization, fissuring, nebulitic rocks, resorption, and ptygmatic or fluidal folding, and injection.

Early foliation. That the Grenville gneisses possessed a foliation due to recrystallization previous to the intrusion of the syenite, is assumed rather than proved, for the reason that it is difficult to con-

ceive of so intimate an injection of sedimentary beds by igneous material, as here exists, unless the formation had been previously metamorphosed. It is quite possible, however, that this metamorphism may have been accomplished by conditions attendant upon the intrusion of the actual magma which is invading them. In any case some modification of the previous texture must certainly have been accomplished previous to the intrusion of the granites, by the intrusion of the syenitic magma and by the intense lateral compressive forces which were operative during, and immediately succeeding this intrusion. Inclusions of gneiss are often contained in the syenite, whose foliation is at an angle to that of the inclosing rock, and dikes of syenite with massive texture have been found crossing well-foliated pyroxene gneisses; but these facts do not prove the existence of a foliation previous to the *beginning* of the intrusion of the syenite, since similar phenomena may be observed in the case of limestone inclusions whose foliation was developed, through contact metamorphism, by the syenite which is inclosing and cutting it.

Pegmatitized and recrystallized gneisses. These gneisses form a narrow shell around the Clark pond granite batholith. Perhaps because of their hard, compact, quartzose nature, the pegmatite veins were unable to inject them so thoroughly in discrete veins as they did the rest of the Grenville gneisses. Instead of forming well-defined veins parallel to the foliation, the pegmatitic material has assumed the form of lenticles arranged *en echelon* between similar lenticles of recrystallized gneiss; or it has impregnated the gneiss very irregularly, diffusing into the rock from the foliation planes; or it may be practically lacking altogether in the more quartzose and compact rocks (plates 15 and 16).

As the granite core is approached from the outside, the gneiss becomes broken into large and small, more or less rectangular blocks, between which granite dikes have penetrated. From these dikes granite and pegmatite veins offshoot parallel to the foliation of the gneiss, while adjacent to the granite core some of the fragments are so granitized that little except the structure remains. The granite is thus surrounded by an encasing belt of brecciated gneiss, and it is quite impossible to draw anything but an arbitrary boundary between granite and gneiss, as there is an irregular gradation throughout, both in a decrease in the number of inclusions and in an increase in their granitization. The granite which thus intrudes the gneiss often shows in turn a well-developed foliation due to recrystallized shreds of Grenville, which are still preserved.

The foliation of the gneiss, best shown just south of Lake Bona-

parte, owes its appearance, in addition to the pegmatite lenticles previously mentioned, to the mineral segregation into bands and lenticles which took place during recrystallization, and to an exceptionally marked development of a dimensional orientation of the minerals parallel to the banding. This orientation extends not only to sillimanite and biotite, which so often exhibit such a character, but also to garnet, cordierite and quartz which have crystallized in forms flattened parallel to the foliation, irrespective of their normal habit. The rocks must therefore have been under intense lateral compression during the period of their recrystallization.

That the rocks are actually a product of recrystallization, and not of dynamic metamorphism, is indicated by the entire absence of evidences of crushing, by the frequent presence of spinel, and by the sutured or dovetailed manner in which the recrystallized quartz grains interlock (plate 15, lower figure). This latter texture occurs in a narrow band of contact metamorphic rock around the California granite batholith, and in this district has been found only in the recrystallized gneisses or in contact metamorphic rocks. Weinschenk (1912, 246) states that this is a texture which quartz usually assumes under the influence of contact metamorphism, and spinel is a typical contact metamorphic mineral.

The small island at the southwest end of Lake Bonaparte is formed of recrystallized pyroxene gneisses, with but rare pegmatite veins and no actual evidence of pegmatitization. The rocks consist of alternating beds of augite, hornblende, scapolite and hypersthene gneiss, and resemble streaked gabbro except for the more uniform character of the bands and the presence of deeply weathered portions from which residual calcareous matter has been dissolved. The foliation is apparently due to recrystallization, with the preservation of original composition differences arising from primary bedding. Within each band the dimensional orientation of the minerals adds to the foliated appearance. The texture is the usual granular mosaic characteristic of these rocks.

Injection gneisses. The injection gneisses include most of the quartz-biotite gneiss of the northwest district, much of the curving belt of gneiss running through the town of Pitcairn, the pyroxene gneisses and the gneiss between Diana and Natural Bridge. On the one hand, these rocks grade into those previously described, while on the other hand, with an increasing intensity of injection they pass into relic gneisses and finally into resorption or reaction gneisses. With continued injection or a renewal of injection, these gneisses may in turn pass into a second generation of injection gneisses. Peg-

matitic facies of both the younger granites and the syenitic magmas have formed injection gneisses; but the latter are less important, occupying only about 6 square miles, while the remainder are of the granitic type.

Syenitic injection gneisses. Normal syenite injection gneisses are rather rare; but just north of Lake Bonaparte pyroxene gneisses are shredded and intensively injected by normal syenite veins. The injection locally is on as intimate a scale as that of the granites, but is usually of a coarser type. Often the syenite forms a lenticular meshwork of veins which weather out in relief inclosing fragments of pyroxene gneiss which form depressions (plate 22, upper figure).

The southeastern portion of the mass of pyroxene gneiss, running northeast from Harrisville, is thoroughly injected by syenitic veins in a very intimate manner, forming a red and green banded rock. Similarly the band of pyroxene gneiss included in the granosyenite east of North Croghan, is thoroughly injected by veins of granosyenite, often on so fine a scale that the alternating bands are less than a millimeter in width and, striped in red and green, present a striking appearance.

The Grenville gneiss between Diana and Natural Bridge is so injected with pegmatitic veins of granitic nature, although genetically connected with the syenite, that much of the rock could more aptly be termed a relic gneiss as only thin films remain between the pegmatite veins (plate 17).

Most of the granitic veins connected with the syenites have a porphyritic texture which serves to distinguish them from those of the younger granites. They have resorbed some of the material from the country rock which has recrystallized to form pyroxene, biotite, garnet or titanite, as the case may be.

The dominant element in the foliated appearance of the rocks is of course the banding due to injection; but the minerals also show the usual dimensional orientation, and in addition all the syenitic injection gneisses, except those north of Lake Bonaparte, have been granulated and pulverized (plate 17, lower figure). The resultant cataclastic texture is in strong contrast to that of the granitic injection gneisses and will be referred to again.

Granitic injection gneisses. The pyroxene gneisses, along the northwestern border of the band near Harrisville, are injected by granite veins which may be either red or, more often, bleached to a white by the calcareous matter of the gneiss it is intruding. The foliation differs from that of the syenitic injection gneisses in that the granite veins show only a protoclastic texture and the rocks do

not exhibit cataclastic textures. The texture of the Grenville portion of the mixed rocks is that of a mosaic in which the feldspars contain numerous inclusions.

Some of the gneiss, within the belt running through Pitcairn, is an injection gneiss, but most of it has been so thoroughly injected and disintegrated that it can be more advantageously treated with the resorption and relic gneisses.

Relic and resorption gneisses. Sederholm has used these terms to designate gneisses in which the country rock has largely disappeared in the invading magma, leaving only relics and impressions behind. Within this quadrangle such gneisses characterize the northeast, or Edwards belt, of mixed gneisses; the gneiss wrapping around the California batholith; and much of the belt running through Pitcairn; in all about 28 square miles. They have arisen in two different ways: on the one hand, through the inclusion of blocks of Grenville and their granitization or disintegration in the invading granite magma itself; on the other hand, through belts of Grenville becoming injected, disintegrated or even resorbed by reaction with pegmatitic materials given off by the granite and forced through and through the sedimentary mass under high pressure, for the most part following the foliation planes with little apparent disturbance.

Throughout all these rocks, thin black beds of amphibolite (pyroxene and hornblende gneiss) and pure quartzite have escaped the injection and dissipation which their inclosing beds have suffered. So great has been the volume of injected material that in many places the whole mass has acted essentially as a plastic body, and movements within it have rotated and displaced the recrystallized amphibolite bands so that they now assume the appearance of lenticular inclusions or long narrow bands, terminating abruptly with blunt rounded ends.

Edwards area. This mass of mixed rock is formed by a core of granite (which locally has assumed the character of a resorption gneiss through reaction with some of the Grenville material) surrounded by a border of resorption and relic gneiss, the product of intense pegmatitic injection into Grenville beds. Large blocks of rusty sillimanite, biotite and garnet gneiss still remain as granitized, recrystallized formations within the granite. White crystalline quartzites and thin, black, lenticular pyroxene and hornblende gneiss beds, within the Grenville, have also, as usual, escaped the shredding, injection and dissipation which the inclosing beds have suffered.

The granite core of this mass weathers more or less rusty and often presents the typical crenulated, gneissoid and banded

appearance of the Grenville, or shows, outlined on the weathered surface, the pattern of an eruptive breccia formed by granite intruding gneiss. These appearances are proved to be largely illusory, however, when we come to examine fresh surfaces and to study thin sections of the rocks. Then we find that the original Grenville gneiss has played in part but a phantom role, leaving the impress of its structure upon the rock without a corresponding change in composition, as the rock is actually granite.

That resorption of the Grenville has taken place is shown by the fact that while the normal granite elsewhere carries but a trace of biotite, here that mineral forms up to 10 per cent of the rock. Pegmatite veins, which also cut the gneiss, carry garnets which were undoubtedly formed from assimilated material. Assimilation has had only a slight influence, however, in changing the character of the granite.

The biotite in the gneiss is often irregularly distributed but is always in very good dimensional orientation and accentuates the gneissic structure of the granite itself. The biotite has the appearance of crystallization from the magma, as little evidence of resorption effects is apparent.

The borders of the core retain little more than the structure of the Grenville gneisses but these rocks are pegmatitic, rather than granitic in nature. The foliated structure, which is so conspicuous on the weathered surface, may be due to the weathering out in relief of pegmatite veins which are separated from each other by only thin films of biotite-garnet gneiss, or to the dimensional orientation of the biotite flakes themselves.

The proportion of original Grenville gneiss in these rocks is so small (not over 25 per cent at most in many of them) that relic gneiss or in many cases resorption gneiss, is a more appropriate name for them than injection gneiss. In many thin sections it is utterly impossible to discriminate between pegmatite veins and the original gneiss; and it is very doubtful if in much of the rock any of the latter is indeed left unresorbed.

Some of the resorption gneiss was later injected by more garnetiferous pegmatite veins and we have an injection gneiss of a second cycle, as in the Pitcairn belt.

Pitcairn belt. The Pitcairn belt of gneiss exhibits the Grenville in all stages of injection, from rock in which there is a narrow pegmatite vein only every few inches (plate 18, upper figure), to one in which adjoining pegmatite veins have coalesced and the rock consists wholly of pegmatite with an excess of biotite which has crystal-

lized out from reaction with the country rock. Even this is not necessarily the end product of injection for such a rock may in turn be injected by pegmatite veins of a younger age, as is the case near Pitcairn, thus giving rise to an injection gneiss of the second generation (plate 20).

Between the stages of normal injection gneiss and reaction gneiss come the relic gneisses in which fairly well individualized schlieren-like streaks of the original Grenville gneiss still persist between and within the pegmatite veins. Gneisses of this character are well exemplified by that about a mile northeast of Geers Corners (plate 18, lower figure). The Grenville gneiss here has been injected, shredded and disintegrated by pegmatite veins until they form 75 to 80 per cent of the volume of the rock. Fragments of the gneiss, however, still preserve their individuality, as visible both in the hand specimen and in thin section. These relics consist of garnet, biotite, sillimanite and quartz aggregates suspended in a ground mass of pegmatite.

West of Pitcairn the rock turns and trends west, thus striking at a large angle to the prevailing foliation. As a result of the lateral compressive forces, acting immediately after the pegmatite injection and before its complete consolidation, the foliation in the field exhibits a crenulation whose axes are approximately at right angles to the banding. The texture of the pegmatite veins is protoclastic within this portion of the belt, the feldspars being granulated on the borders but the quartz uncrushed. On the other hand, the pegmatite veins in the band northwest of Greenwood creek, parallel to the compressive forces, wholly lack protoclastic texture.

Biotite-garnet gneiss belt. This belt of relic gneiss is so thoroughly mixed as to present a persistent character throughout. The original Grenville gneiss has been about as completely injected, pegmatitized and disintegrated as it well could be without actually losing all its individuality.

As seen in the hand specimen (plate 19, upper figure), the rock presents a narrow parallel banding due to alternating stripes of white pegmatite and light bluish gray gneiss. In thin section the latter, in turn, is found to be injected and impregnated with pegmatitic material and often shredded by the pegmatite veins. The coarse injection of the hand specimen is repeated on a microscopic scale in the darker colored gneiss band itself. Small bits of the original gneiss, consisting of a fine-grained, mosaic-textured aggregate of biotite, quartz, feldspar and garnet, interleave with, are inclosed by, or are forced aside by, and wrap around, pegmatitic material (plate

19, lower figure). This localization of the biotite in thin strips distinguishes the relic gneisses from the more homogeneous resorption gneisses. Many of the garnets contain poikilitic lenses of quartz, elongated parallel to the foliation.

Palimpsest texture. A unique and apparently anomalous feature of certain of these rocks is the angular relation which the orientation of the minerals of the pegmatite veins bears to the biotite of the Grenville portion of the rock. A new foliation has been written over or superimposed upon the preceding foliation of the Grenville, at a high angle, without destroying it.

A specimen of the gneiss (plate 21) was taken from a point about a mile and a half southeast of Balmat Corners, and the surface etched with a mixture of hydrofluoric and sulphuric acids, to bring out the details of the structure. The gneiss is thoroughly injected, and almost completely disintegrated, by pegmatite. In those remnants of the gneiss which retain their structure the biotite flakes and the quartz are oriented parallel to the banding; but in the pegmatitic material, the quartz and feldspar, together with the biotite which has been gathered in from the gneiss, are all oriented at right angles to the banding, and hence to that portion of the biotite and quartz of the Grenville gneiss which has retained its individuality. Thus we have two foliations at right angles to each other in the same rock, one written over the other without completely destroying it. Such an example as this can not possibly be due to ordinary dynamic metamorphism with contemporaneous recrystallization, or all of the biotite would have been oriented parallel to the quartz and feldspar, since it is ordinarily one of the easiest minerals to recrystallize. The difference in grain between the pegmatite veins and the gneiss also militates against such an explanation.

Furthermore, this is not an isolated case. In a specimen from about a mile south of the Alpina road, near the north fork of Rockwell creek, a similar phenomenon occurs. Pegmatite veins ⅛ to ¼ inch thoroughly inject a biotite gneiss of the Grenville series (plate 19, upper figure). The strikes of the foliation of the pegmatite veins and of the gneiss are at an angle of 45°. Other specimens show similar phenomena.

A detailed study of this texture has not been made, but it is suggested that the foliation of the Grenville gneiss antedated the incoming of the pegmatite veins, and that the foliation of the latter was induced while they were in a still fluid state.

Variable texture. Another feature, hard to explain by recrystallization accompanying dynamic metamorphism, is the variation in

texture between the pegmatite veins and the intruded gneiss. Thus the pegmatites may be much coarser grained, with large, elongated lenses of quartz, while the Grenville may be fine-grained, with a mosaic texture. Again, the pegmatite veins may exhibit a protoclastic texture in which the feldspars are granulated, while the Grenville portion may show only recrystallization textures.

Protoclastic texture. Reference has already been made to the protoclastic texture and crenulation of some of the pegmatite veins, where they are oriented at right angles to the prevailing direction of the foliation, indicating the influence of a controlling force oriented in a northwest-southeast direction. Further evidence of the dominant influence of such a lateral compressive force, during the time of intrusion of the pegmatite veins, is given by the veins about a half mile west of the central part of Indian Lake. Here coarse pegmatite veins from 1 to 3 feet wide are intruded both parallel to and across the foliation of Grenville gneiss. Their crystals average from 1 to 3 inches in diameter. The foliation of the veins injected parallel to the foliation planes of the gneiss is parallel to that of the gneiss, but the foliation of the cross-cutting veins is also parallel to that of the gneiss, and hence often oriented at considerable angles to the direction of the veins. In thin section the borders of the feldspars of the pegmatite are crushed and granulated, while the quartz, although smeared out in long lenses, is clear and unmashed.

Flow phenomena. These gneisses in the field frequently exhibit phenomena which can only be interpreted in one way—actual flowage of the rock. That this took place while the rock was at least partially molten, is indicated by the total absence of cataclastic textures, together with other features.

Thus at one locality in the Edwards area a lens of amphibolite in the gneiss has been broken up and the fragments have been rotated and displaced. The flowage lines are parallel to the sides of the fragments, indicating that the phenomenon was one of flowage while the relic gneiss was in a partially liquid state. The appearance is as though a sedimentary gneiss were injecting, in eruptive fashion, one of its own beds.

Lenses of amphibolite, with blunt rounded ends, which have been pulled apart and separated from each other, are very common throughout all the relic and resorption gneisses as are also long, narrow, intercalated beds which suddenly end, without any of the other fragments being present within many feet (plate 22, lower figure).

In the Pitcairn belt, about a mile northeast of Geers Corners, inclusions of white quartzite and garnet gneiss occur in an appar-

ently bedded gneiss, which is actually a biotite garnetiferous granite resorption gneiss. Here also the rocks are cross crenulated, and yet the pegmatite veins show only protoclastic textures. This cross crenulation, without cataclastic crushing, is also well illustrated in the relic gneiss at the northeast end of the California batholith.

The palimpsest textures, previously mentioned, also indicate that many of the phenomena of crenulation, displacement of included relics and apparent intrusive relations may have taken place while the granitic materials were still partially fluid. In view of the fact that the intruded and injected materials form over three-fourths of the rocks, such fluidal phenomena are to be expected.

Cataclastic texture. Miller, in presenting an argument for the origin of the early foliation of the Grenville gneiss in the Adirondack region, by a process of static metamorphism, writes (1916, 608), "Again the general lack of notable granulation in the oldest rocks of the region—the Grenville—is not compatible with the idea of production of cataclastic structure in the intrusives by lateral pressure, else why were the still older rocks not proportionally affected?"

In the summary of the origin of the foliation of the syenitic rocks, it was stated that this foliation was induced by intense lateral compressive forces, of such strength as to mash a band of igneous rock 5 miles wide even after part of it was in a solid state. Since the Grenville gneisses are older, they too must have been subjected to the same stresses and, since they are weaker, they too should have been notably granulated. Within this quadrangle this is exactly what is believed to have happened to the Grenville gneisses; they were notably granulated; part of them still are (about 5 square miles) but the dominant portion was recrystallized and to a slight extent resorbed by younger pegmatitic and granitic injections. The reasons for this conclusion are as follows:

The Grenville gneisses, where injected with pegmatite veins or modified by granitic juices of the younger granites, are recrystallized; but, in general, where injected by facies of the older syenite and not affected by extracts from the younger granites, they, together with the injected syenitic rock, are in a crushed condition with a cataclastic texture. This is well exhibited in the pyroxene gneiss band. The northwestern portion is injected by granitic pegmatitic veins and exhibits no evidence of crushing; the southeastern half is injected by syenite and, together with the latter, exhibits a cataclastic texture. The granitic veins which inject the gneisses and are crushed are believed to belong with the syenite, and not with the

younger granites, because they occur only near, and in association with, the syenite; because granitic pegmatitic facies, some of which are cut by hyperite dikes, have been repeatedly observed to develop at the contact of the syenites with the Grenville; because they show the typical porphyritic texture of the syenites; and because they are crushed and are the only granitic veins which show a cataclastic texture.

The limestone beds, through their facility to dissipate the stresses by recrystallization and flowage, have protected some quartzose beds, intercalated within them, from crushing, and perhaps the same may be the case with the pyroxene gneisses on the island in Lake Bonaparte, although these do show some evidences of crushing, but these are merely particular cases of local importance.

Thus it is concluded that, as indicated by the evidence and as is *a priori* probable, the Grenville gneisses were crushed and granulated. The modification of that portion which is now recrystallized was accomplished by the pegmatite veins and granitic juices of the younger granites. The volume and importance of these materials injected into the recrystallized Grenville gneisses, as just described, render their competency to accomplish the recrystallization beyond question, even if the direct evidences of their effect were not present. Among these are: the occasional traces of spinel, a typical contact metamorphic mineral; the sutured and dentated manner of interlocking of the quartz grains, which is also typical of contact metamorphism; the resorption and recrystallization of biotite; and the palimpsest textures which have arisen through recrystallization.

CONTACT METAMORPHISM

The term "contact metamorphism" is used for the changes which are induced, in an intrusive mass or the country rock adjacent to their mutual contact. In this district it is but a local phase of the general process of igneous metamorphism which on a regional scale has been responsible, mainly by means of pegmatite veins, and juices for the recrystallization of nearly all the Grenville gneisses of the area. In many cases it is impossible to separate the results of contact metamorphism from those of the more general process, since the one grades into the other. This is especially the case around the Clark pond batholith.

Gabbros, syenites, fine-grained granites and porphyritic granites have all produced their own local contact metamorphic zones.

Contact metamorphism includes changes both in the intruded

igneous rocks and in the country rock near the contact, classified under endomorphic and exomorphic changes respectively.

Endomorphic Changes in Syenite

The main mass of the syenite, where it joins the Grenville, is usually much finer grained, equigranular, and massive or showing only slight traces of crushing, in contrast to the coarse porphyritic cataclastic texture of the main body. Many of the syenite dikes in the limestone and locally part of the main syenite mass near the contact become bleached and weather to a light gray or white. This is a similar effect to that induced in much of the finer-grained granite in contact with, or cutting, the limestones.

Titanite. Titanite is almost a constant accessory mineral of the syenite near contacts, although normally absent or very rare elsewhere. It is in irregular grains, and may occur in considerable quantity, 5 per cent or more. It makes no difference as to what facies of the syenite is the intruding rock; for titanite occurs in the granosyenite intruding the Grenville near North Croghan, in the syenitic gabbro west of Indian Pond, and in all, or any, of the intermediate facies affected by contact metamorphism. Not only does the syenite contain titanite, but it has often introduced the mineral in considerable quantity into the adjoining limestones, where it forms one of the typical contact minerals. The clue to the origin of this titanite, or of the titanium, is found in the occurrence of titanite in basic segregations within the syenite mass. Here the titanite is associated with magnetite, which was one of the last minerals to crystallize and must be of pneumatolytic origin, although belonging to the magmatic stage of crystallization. The titanium, then, was normally held in solution by the mineralizers until a late stage of differentiation; but when the syenitic rock came in contact with limestones or calcareous gneisses, it was either precipitated as titanite in the syenite itself, or was carried into the surrounding rock by the gases or solutions and there deposited. This early precipitation of the titanium as titanite, near contacts in the syenite, may be due to lime dissolved from the country rock and diffused through the molten mass by migrating mineralizers. It may be of some significance that the fine-grained boss of syenite east of Lake Bonaparte, which cooled too suddenly and was too large to permit the diffusion of lime from the borders, contains abundant rods of ilmenite instead of titanite.

Graphite. Near and at the contacts of the syenites with the lime-

stones, and in dikes and sills of syenite within the limestones, flakes of graphite have been repeatedly observed abundantly disseminated through the syenite. It has not been observed anywhere within the main mass of the syenite away from the contacts. This graphitic content is particularly noticeable in the region around and north of Natural Bridge. The syenite penetrates the limestone very irregularly here and often contains abundant disseminated crystalline flakes of graphite. It is cut by quartzose pegmatite veins which also carry coarse scales of graphite. Although the limestones themselves carry graphite, there are good reasons for believing that the graphite in the syenite is not a result of assimilation, but rather of reduction of carbon dioxide to graphite by gases given off from the magma, somewhat as suggested by Winchell (1911). Carbon dioxide in considerable quantity would have been liberated through the silication of the limestone, and may then have diffused through the adjacent molten rock. The syenitic rocks which thus carry graphite are neither less quartzose nor more calcic than normal variable facies of this rock, and assimilation or reaction of quartz with the lime is therefore improbable. Moreover, the amount of graphite in the syenite is comparable to that in the limestones and hence if it were derived from this source, would mean that the syenite had actually replaced the limestones to the extent of its own volume, retaining only the graphite.

Fissuring and pyroxene veins. Another feature, particularly well shown along the northern contact of the band of limestone running east from Natural Bridge, is the fissuring of the syenite and the deposition in the fractures of veins of dark green pyroxene or of pyroxene and feldspar or more rarely of pyroxene and scapolite. Coarse pegmatite veins of feldspar, quartz and pyroxene, with porphyritic feldspars up to 5 inches in diameter, are also common. Another example, on a more extensive scale, is found along the northern edge of the pond about half way between Indian lake and Lake Bonaparte. Here the fine-grained syenite, for several hundred feet from the contact with the limestone, is reticulated with a fine network of dark pyroxene veins which give the appearance of an eruptive breccia.

Endomorphic Changes in Granite

The chief contact metamorphic effects on the granites are local bleaching, occasional slight assimilation, and rarely a fissuring of the granite and deposition of vein materials in the fractures.

Bleaching is almost exclusively confined to the contacts of masses and dikes of the fine-grained granites with lime-stones, where the pink color becomes bleached to white. A similar change is described and discussed by Cushing (1910, 177-80) in the Thousand Islands region. A bleaching of the green syenites, along some of the contacts with limestone, has just been referred to. This feature has not been noticed in portions of the porphyritic granite which can be positively identified, although white dikes of porphyritic granite are intruded in the relic and resorption gneisses of the Edwards area.

All the granites may be locally tainted with material derived from reaction with portions of the country rock. Thus sheets of porphyritic granite, where they are intruding gabbro, may locally react with some of the basic material and assume the appearance of a transitional phase between the two rocks. The fine-grained granites often contain xenocrysts of enstatite, hornblende, monoclinic pyroxene or biotite, where they are cutting amphibolites. Another result of contact metamorphism is the coarsening of the grain and change of color from pink to green in the granite of the California batholith, on its borders, where it contains inclusions of amphibolite.

At one locality only were veins of pyroxene observed in the granite. This is on the south side of the little pond about half way between Indian lake and Lake Bonaparte, and opposite the locality where the syenites are cut by the criss-crossing veins previously described.

The fine-grained granite masses have been far more effective agents of contact metamorphism than the porphyritic granites. The major portion of the gneiss belt surrounding the Clark pond batholith might be described as a contact metamorphic aureole in contrast to the prevalent injection character of the gneisses associated with the porphyritic granites. High temperature effects are also indicated by the occasional presence of enstatite gneiss layers included in the granite of the California batholith, and representing metamorphosed carbonate layers. The most noteworthy effects of contact metamorphism of the fine-grained granites is found in the reaction rims of garnet gneiss which surround them almost uniformly at their contact with the adjoining Grenville gneisses.

Garnet Rock

The most persistent band of well-characterized contact metamorphic rock which occurs in this district is the garnet gneiss, with asso-

ciated pyroxene gneiss and amphibolites, which surrounds both cores of the California granite batholith and its associated intrusive sills. Except for a short distance, about a half mile east of the California schoolhouse, the garnet rock can be traced, outcrop by outcrop, around the entire batholith, or as much of it as is exposed on this quadrangle. The thickness of the band of garnet gneiss and dark gneiss is about 100 feet. The garnet rock itself, as seen in the field, is coarse-grained, composed of abundant amethystine to dark red garnets, averaging ¼-inch in diameter, quartz and feldspar. Associated with this light colored garnet gneiss are dark pyroxenitic or amphibolitic beds, locally carrying grains of pyrite and weathering rusty. The rocks are very much broken up by crosscutting pegmatite veins, some of which are rich in tourmaline. Locally, in the vicinity of the latter veins, the garnet rock has again suffered contact metamorphism and contains abundant large black tourmaline crystals, averaging ½-inch across.

A typical section of these gneisses from the northeast end of the batholith is given here. It illustrates how the granite, as well as the sedimentary gneiss, is affected by the contact metamorphism, and how the granite intrudes the gneiss in sill-like form and tears away fragments and long stringers as inclusions.

The strike and dip of the granite are the same as those of the overlying gneiss. Approaching the gneiss from the normal granite, the latter begins to contain elongated inclusions of pyroxene gneiss. As these become abundant, the granite assumes a coarser grain and changes from the normal pink to a greenish hue, weathering white. This zone is about 50 feet wide. Then comes 15 feet of granite gneiss with several thin sheets of highly garnetiferous rock, succeeded by the contact metamorphic gneisses. The complete section, as exposed, is given below:

Feet	*Character of Rock*
	Medium-grained, greenish granite gneiss
60	Garnet gneiss
30	Pyroxene gneiss with thin rusty beds
40	Garnet gneiss
15	Medium-grained, greenish granite gneiss with several thin bands of garnet gneiss averaging about 6 inches thick
50	Medium-grained, greenish granite gneiss with schlieren of black gneiss
	Normal fine-grained pink granite

At a section ¼ mile southeast of Kellog Corners, a band of garnetiferous gneiss about 40 feet thick, overlying limestones, is itself overlain by a sill of fine-grained pink granite, dipping at an angle of 40° north. The contact between the granite and the garnet gneiss is absolutely sharp, and the granite is of normal character up to the contact. This sill of granite is also overlain by the same type of gneiss. The sill near the southwest end of the main mass of the California batholith is also bordered on each side by garnet rock. Several small individual sills of the granite in the limestones are also accompanied by garnetiferous zones commensurate with their size.

In the case of the main batholith, thin beds of black gneiss usually intervene between the garnetiferous facies and the granite.

In three thin sections examined, from widely separated localities, the character of the garnet rock is found to be more variable than the uniformity of appearance in the field would lead one to suspect. They are alike, however, in that garnet is the chief constituent of all. All show a pronounced gneissic structure, which is quite indistinct in the rock itself. The garnets may be more or less equidimensional, or may be in elongated growths parallel to the foliation. They are always poikilitic, with abundant inclusions oriented parallel to the foliation, and may or may not show actual, or skeletal, crystal outlines. Microperthite, andesine and quartz are present in varying amounts in all the rocks, and ilmenite is a common accessory. The quartz is in elongated lenses composed of grains dovetailing and interlocking by sutures, a typical contact metamorphic texture. In one section the rock consists of alternating lenses of quartz and of bundles of sillimanite fibers, with accessory microperthite, oriented parallel to the foliation and curving around the more or less equidimensional garnets. Another carries more microperthitic feldspar, the garnets are in elongated forms, and sillimanite and quartz are abundant. The third carries no sillimanite, but its place is taken by brown biotite and a deep green spinel. The latter occurs as irregular inclusions in the garnet and as small grains in the biotite.

A thin section of one of the dark gneiss beds shows it to consist chiefly of an allotriomorphic, granular aggregate of pyroxene and labradorite. Quartz, with the usual contact metamorphic texture, garnet, biotite, enstatite and ilmenite, are accessory minerals.

The greenish colored granite, which contains inclusions of the dark gneiss, shows in thin section irregular grains of enstatite and hornblende and large areas of quartz composed of grains with sutured

contacts, in addition to the usual microperthite, andesine and quartz of the normal granite.

One of the striking features which these beds of garnet and dark gneiss show by their present distribution is that they were formerly continuous over the top of the batholith. The limestone area separating the two parts of the batholith, in the southwest, is but a synclinal trough resting in a corresponding depression in the surface of the granite, between two anticlinal axes, which correspond to the two cores of the batholith. The southwestern nose of the main mass of granite can be actually seen to plunge towards the southwest beneath an asymmetrical arch of garnet and pyroxene gneiss. The gneisses change from a moderate (30°) westward dip on the northwestern side, to a more or less nearly vertical dip on the southeast, passing through a horizontal position on the crest of the batholith. On the northwestern dip slope of the gneisses there are several little, southwesterly pitching, synclinal troughs in which limestone still remains, and contitutes the projecting fingers of the main area shown on the map. About ¾ mile north of this southwestern tip, the top of the batholith is not yet completely exposed from beneath the cover of these gneisses, and alternating exposures of granite and garnet amphibolite gneiss appear, the latter masses not over 10 feet thick with a low westerly dip, and resting as a thin, patchy veneer on the surface of the underlying granite. They are reticulated with pegmatite veins. About a mile southeast of East Antwerp, also, essentially horizontal beds of gneiss, thrown into minor open folds, still rest on the surface of the granite. The gneisses on the northwest side of both the major and minor batholiths have a moderate, 20°–35°, dip northwest, while on the southeast side of both masses they are in more or less vertical attitudes. At the northeast end of the main batholith the gneisses dip about 45° to the north or northeast. The foliation of the granite corresponds in detail to the foliation of the adjacent gneiss, whether it be moderate west or vertical. There can be little doubt that both parts of the batholith were formerly covered with a roof of these contact metamorphic gneisses.

It is the irregular wavy surface of the granite, resulting in puckers or minor folds in the overlying gneisses, combined with the depth to which erosion has proceeded, that has resulted in the irregular border of the southern edges of both the northern and southern masses.

Martin (1916, 24–30) has described similar belts of rocks at the contacts between similar granite and the Grenville of the Canton

Quadrangle. He has considered the rocks to be fragments of a sedimentary series, and not of contact metamorphic origin, because of the failure of the rock to form an uninterrupted zone around the granite, its resemblance to other garnet gneisses of admittedly sedimentary origin, and the inclosure of a thick strip of apparently sedimentary garnet gneiss near the west border of the granite.

The junior author has found that a similar belt of garnetiferous gneiss wraps around a batholith of similar fine-grained granite at several other localities, including the following: the granite batholith mapped by Cushing north of Gouverneur, and the granite batholiths west of Payne lake and west of Macomb on the Hammond quadrangle. It seems very improbable that at so many widely separated localities the same granite has intruded the same thin stratum of such a thick series of rocks. A more probable explanation is that the garnet gneiss is the result of intrusion of the granite between beds of the Grenville series along its outer borders; a partial reaction of the granite with the aluminous and quartzose schists producing the garnetiferous gneiss (which as noted carries considerable sillimanite, and accessory spinel, entatite etc.), and a contact metamorphism of included carbonate beds to pyroxene or amphibolitic gneisses.

Exomorphic Changes[1]

Local masses of minerals, formed through the interactions of solutions, given off by the magmas, with the adjoining limestones, are a common phenomenon of contacts, both of the main masses and of moderate sized dikes. Among the most common of these minerals are great granular masses and pockets of pale green pyroxene or coccolite, colorless diopside, dark green pyroxene and feldspar. In smaller masses, but just as widely distributed, are scapolite and phlogopite. Tremolite and enstatite are locally abundant. Wollastonite, titanite, garnet, pyrrhotite and pyrite are common accessory minerals. Apatite and zircon are present, but rare. At one locality a magnetite body is probably of contact metamorphic origin.

[1] Since this paper was written, a careful study of the mineralogy of certain contact deposits in the Natural Bridge area has been made by W. M. Agar (Contract metamorphism in the Western Adirondacks, Proc. Amer. Phil. Soc. v. LXII, 1923). He finds that the syenite has produced mineral associations characteristic of a higher temperature than those produced by the granites; that titanite, micoperthite, diopside-augite, diopside, meionite, wernerite, apatite, wollastonite, spinel and zircon are developed; that hornblende and titanite are missing; and that the meionite variety of scapolite is characteristic of the syenite and marialite and missionite of the granite contact deposits.

Contact metamorphic minerals formed at contacts of igneous rocks and Grenville gneisses are commonly garnet, cordierite, sillimanite, hypersthene and quite often spinel, in addition to biotite, feldspar, hornblende etc.

Locally the limestones in the vicinity of large or abundant dikes are recrystallized to a much coarser grain. Occasionally also the calcite assumes a blue color.

Pyroxene. Pyroxene is probably the most widely distributed and forms the greatest bulk of the contact minerals. It is impossible to distinguish between actual contact metamorphic phases of this mineral and deposits or beds which were formed at too great a distance from any magma to be included under this term. The two most common modes of occurrence are as coarse, white, massive aggregates of diopside, and as pale green, granular masses of coccolite. Diopside also occurs widely distributed as small crystals, disseminated in the limestones, and as nodular aggregates, often altered to serpentine, or as veins in the limestone. Dark green pyroxenes form smaller pockets in the limestones, often with well-developed crystals, and they also constitute the majority of the veins in the igneous rock. Like the diopside, they may be found as disseminated small crystals. About ½ mile northeast of Natural Bridge on the hill overlooking Indian river, inclusions of limestone in syenite are completely altered to masses of dark green pyroxene and scapolite, with some titanite. Pockets with well-developed crystals are frequent along the south side of the limestone band east from Natural Bridge, and at numerous other localities.

Feldspar. Feldspar locally forms quite large pockets at the contact of the limestone and syenite. But usually it is associated as an accessory with other minerals. Microperthite is the predominant variety.

A very peculiar bed of feldspathic limestone, presumably of contact metamorphic origin although only a thin sill of igneous rock is actually in contact with it, occurs in the hill about ½ mile north of Harrisville. The limestone is intercalated between beds of dark pyroxene gneiss which are intensively intruded by syenite sills. A narrow sill of syenite, only a few feet thick, intervenes between the limestone and the gneiss. The limestone bed is about 40 feet thick, the upper 15 feet being a coarse, white, crystalline rock with nodules and warts of serpentine and abundant disseminated pyroxene crystals; the lower portion, about 25 feet thick, is a calcareous feldspar-pyroxene rock, with occasional nodules of pyroxene, feldspar and phlogopite. This rock weathers a rusty brown with a jagged

surface, somewhat resembling a porphyritic igneous rock. Small and large segregations of feldspar, up to 2 feet in diameter, are common. The contact between the white limestone above and this rusty, feldspathized phase is quite sharp, and the two portions can be traced along the strike for a considerable distance. In thin section the rock is found to consist of microperthite and diopside embedded in a ground mass of calcite. The pyroxenes are often in well-rounded grains. The microperthite is granulated on the borders, although the pyroxenes are not.

Scapolite. Scapolite is commonly in massive aggregates associated with other minerals, but may form distinct crystals disseminated in the limestones. It varies from white to reddish brown or green. On an island in Lake Bonaparte meionite forms interbedded layers with hypersthene and pyroxene gneiss.

Phlogopite. Phlogopite is disseminated throughout all the limestones and is also associated with the contact metamorphic deposits. Considerable masses of phlogopite, associated with dark green pyroxene, occur in a pocket of limestone at a contact with fine-grained pink granite, back of the little pond at the west end of Lake Bonaparte. In a prospect pit here massive aggregates of mica, up to 1½ feet, have been thrown out, and individual crystals up to 6 inches in diameter, but most of the mica plates are only an inch or so across. It is possible that other similar pockets might be found around the border of this mass of granite.

Tremolite. Tremolite is abundant in the serpentinized rocks about ½ mile northeast of Kinsman School. The limestones here are intensively intruded by sheets of porphyritic granite. The tremolite occurs as irregularly oriented, flat, bladed crystals, several inches in length, in a serpentinized groundmass formed by the alteration of the tremolite and, perhaps, other minerals. The tremolite occurs elsewhere as fibrous tremolite schists near contacts of limestones with granite rocks.

Cordierite, spinel, sillimanite and enstatite. It is impossible to separate the portion of these minerals which has feen formed by contact metamorphism by the main igneous masses or their dikes, or by contact metamorphic action of their pegmatite veins, from the portion formed by igneous metamorphism at a distance, since the mineral association may be the same in each case; and although no igneous rock may now appear at the surface in the vicinity, it is impossible to tell how near such a mass may be.

Cordierite occurs in inclusions of Grenville gneiss in the Clark pond batholith and in many of the Grenville relic and resorption

gneisses, formed by the pegmatite veins allied both with the younger granites and with the syenites.

Spinel occurs as small individual grains, as aggregates of minute granules, or as small irregular inclusions in garnet or enstatite. It has been found in the narrow belt of contact metamorphic garnet rock around the California batholith, in inclusions of gneiss, and in gneiss around the borders of the Clark pond batholith, in the relic gneiss west of Blanchard School, and elsewhere. It is deep green to light green and has been identified only in thin section.

Hypersthene is a common mineral in inclusions around the borders of the two granite batholiths, in basic inclusions in the syenite and granites, in the basic bands or amphibolitic rocks in the Grenville gneisses, and in the pyroxene gneisses shredded by syenite north of Lake Bonaparte. It is absent from the normal pegmatitic relic and resorption gneisses and seems to be almost wholly a mineral of contact metamorphic origin. It occurs usually as irregularly embayed grains or as large skeletal growths, with abundant poikilitic inclusions, or in allotriomorphic aggregates. It also occurs as xenocrysts in granite near contacts with the amphibolitic beds.

Sillimanite, like cordierite, occurs both in gneisses of contact metamorphic origin and those of igneous metamorphic origin.

Magnetite-pyrite deposit. About half way between the head of Indian pond and Indian lake, there is an old, abandoned magnetite prospect pit. The place is now overgrown with underbrush, and little can be seen. The magnetite ore vein was apparently several feet wide, inclosed in limestone, and only a few score of feet away at most from basic syenite. The ore is banded, the layers carrying more or less dark green pyroxene associated with the magnetite. Considerable pyrite is disseminated through portions of the ore. This body is interpreted as a contact metamorphic replacement deposit in limestone associated with the basic syenite.

Amphibolites

The term "amphibolite" is a rather comprehensive one, used in the field to embrace gneisses of dark color and basic composition. "Quartz, which is one of the commonest constituents in gneisses, is absent, or is present in very small amount, while hornblende and feldspar, the latter chiefly plagioclase, are the main constituents of the rock. Pyroxene and biotite often replace the hornblende in part." (Adams and Barlow, 1910, 24). Throughout the Grenville series, in the Adirondacks and in the adjoining region of Canada, bodies of

such dark colored, basic material are common. They form but a very small proportion of the rocks in this quadrangle, but are conspicuous because of their sharply defined character in contrast to the light colored inclosing rock, and are interesting in as much as they constitute such a puzzle with respect to their origin. As Cushing (1910, 33) has stated, such rocks may be either of igneous, sedimentary or contact metamorphic origin. The amphibolites of this quadrangle are believed to include only those of igneous and of igneous metamorphic origin, the latter including contact metamorphic rocks. No amphibolites of truly sedimentary origin have been identified. Those of igneous origin are mainly portions of the gabbro masses in which the pyroxene has been more or less altered to hornblende, and they have been already considered. A portion of the narrow, sheetlike masses in the gneisses may be of similar origin, but in many cases it is difficult to say what they were originally.

The amphibolites which are to be discussed here are those which are of igneous metamorphic origin.

Within the pegmatitic relic and resorption gneisses previously described, there are frequent thin, sill-like sheets of amphibolite (plate 22, lower figure) from several inches up to 2 feet wide, the narrower ones being more common. These can rarely be traced continuously for more than 10 feet. They are almost universally broken into fragments by pegmatite veins and are often displaced, their ends then being almost invariably surrounded by pegmatite. The displacement of these inclusions by flowage, while the whole mass was still in a plastic state because of the great volume of at least partially liquid pegmatite, has been described. Because of these phenomena, it is difficult to prove that these sheets do or do not cross the bedding of the gneiss and hence that they are or are not of later igneous origin. With diligent search, however, no positive evidence of such cross-cutting relations was found, which indicates that they may be metamorphosed beds of the Grenville series. This is further emphasized by the fact that occasionally they may be highly garnetiferous or pyritous and weather rusty. In a thin section of a typical specimen hypersthene is one of the principal minerals, and this is indicative of a contact metamorphosed sedimentary bed, since hypersthene has not been found in the known gabbros and is common in some of the Grenville gneisses. Hypersthene gneisses, which have the appearance of amphibolites, have already been described under the pyroxene gneisses.

Occasional small inclusions of amphibolite also occur in the main syenite mass south of the boundary of the Grenville. An examination

of a thin section of one of these proves it, too, to consist of hypersthene and plagioclase mostly altered to zoisite and sericite. Southeast of Tinney Corners there are long amphibolitic inclusions in the granosyenite. These consist of a granular aggregate of hornblende, biotite and oligoclase, with considerable titanite and occasional grains of garnet and magnetite (plate 23).

On the borders of the California and Clark pond batholiths are frequent long, narrow, dikelike sheets of amphibolite or hypersthene gneiss. These are known to be inclusions and not dikes from the facts that they are crossed by pegmatite veins offshooting from the granite (plate 24, upper figure), that their terminations can in some places be found within the granite, and that occasionally granite can be found cutting them. Away from the borders of the batholiths this type of inclusion is the only one found.

One such included sheet, on the western border of the California batholith, is exposed for a length of 200 feet and is only 3 feet wide. It is cut by pegmatite veins and is composed of hornblende, hypersthene and plagioclase in an allotriomorphic aggregate. At least part, if not all, of the hornblende is the result of alteration of the hypersthene. This rock is similar in appearance to the dark gneiss intercalated within the contact metamorphic sedimentary garnet rock on the border. There are also, however, inclusions of amphibolite which in thin section resemble the normal gabbro, and these may indeed be igneous in origin.

In thin sections none of these rocks show any definite succession or order of crystallization for the minerals of which they are composed.

Adams and Barlow (1910, 97 *et. seq.*) have shown that rocks similar in both their character and mode of occurrence to those just described, have been formed through contact metamorphism of limestone beds by granite. The granite has transfused (p. 106) "into the limestone silica, alumina, oxides of iron and magnesia, with some alkalis and a small amount of titanic acid" . . . (p. 107) "In the earlier stage the waters given off by the granite, having accomplished the transference of material into the limestone, passed off with CO_2 in solution. In the later stages of the alteration, however, these waters while continuing to deposit silicates in the limestone made place for these latter by carrying off carbonate of lime in solution." Such a theory seems best adapted to explain the origin of the majority of the amphibolites here described, although it is possible that a part of them may be altered fragments of gabbro.

The sedimentary origin of the amphibolite is indicated by the pres-

ence of hypersthene which in this district is common only in the contacts of igneous metamorphic Grenville gneisses, by the presence of similar beds intercalated within the Grenville gneisses (as on the island at the west end of Lake Bonaparte and in the gneiss around the California batholith), by the occasional rusty and garnetiferous phases, allotriomorphic and granular textures, and the absence of cross-cutting relations where intercalated in the Grenville gneisses.

STRUCTURAL AND HISTORICAL GEOLOGY

Grenville

Here, as elsewhere throughout the Adirondacks, the Grenville limestones and gneisses are the oldest rocks of which we have any knowledge. The ancient basement upon which the materials of these beds—sedimentary as they are in origin—was laid down has disappeared or has been rendered unrecognizable by the succession of great igneous intrusions. The Grenville rocks have been subjected to the repeated operation of lateral compressive forces, arising in part from their shouldering aside by the intrusive batholiths and in part from orogenic forces which affected both the Grenville and the batholiths. The sediments were folded, crumpled, forced aside and torn apart by the intruding batholiths, and injected and disintegrated by the pegmatitic materials given off by them.

The Grenville, as indicated by its mineral character, originally consisted of limestones, shales, sandstones and rocks of intermediate character which, on metamorphism, gave rise to marbles, biotite, cordierite, sillimanite and garnet gneisses and quartzites. How much of the pyroxene and feldspar, now present in many of these gneisses, was formed from original constituents, is an unsolved problem, but certainly much of it is of contact metasomatic origin.

Grenville succession. As a result of so many successive igneous intrusions and of recurrent stresses, the Grenville formations are now so thoroughly disintegrated that little can be made out as to the normal succession. The three separate gneiss belts in the central band may or may not represent the same series. All three present different characteristics in the field although mineralogically they are similar. In the interior of the Edwards area, there are large areas of rusty gneiss which resemble in appearance and mineralogy that around the Clark pond batholith; but the borders of the area, on the other hand, consist of a narrow band of blue-gray, nonrusty gneiss, with biotite and garnets and without the characteristic minerals of the rusty gneisses. The Pitcairn belt is often nonrusty but

is mineralogically similar to the rusty gneisses. Its northern extension, however, is rusty, with intercalated amphibolite, and is not sufficiently exposed to warrant an opinion as to whether it is or is not a different series from the main belt.

The pyroxene gneisses northeast of Harrisville, while probably originally siliceous, are certainly now different chemically from their early character, as a result of igneous metamorphism.

The interbedded quartzites and limestones in the vicinity of the Kinsman school seem to represent a series of beds isoclinally folded, within a southwestward pitching synclinal belt of the garnet-biotite gneiss, and hence to overlie the latter.

The beds will need more detailed study, however, before any definite conclusions can be drawn.

Gabbro

The first igneous rock to be intruded into the Grenville was the gabbro. Its mode of intrusion was dominantly that of the concordant type, that is, intruded as sills along the bedding planes of the Grenville. Of such a character are the lenticular bodies which form a well-defined but intermittent band along the Indian river valley and the continuation of its line of strike northeastward, possessing a width of ¼ to ½ mile and a length of 14 miles, passing off the sheet into the adjoining quadrangles at each end. Similarly the band of gabbro, outcropping discontinuously from Bennet School to Lake Bonaparte, forms a line of lenticular, sill-like bodies which have been forced aside and intruded by younger igneous rocks. The Geers Corners mass is of the nature of a boss, intruding limestones; although it, too, contains long, narrow inclusions of limestone which are oriented parallel to the general trend of the adjoining rocks. What the attitude and condition of the Grenville beds were at the time of this intrusion, is unknown. It is certain that they could not have possessed their present attitude since they were subsequently folded, together with the gabbro sills, as is indicated by the sharp curve of the gabbro in its extension on to the Gouverneur sheet, and as has been proved by Martin in the Canton quadrangle. The gabbro produced numerous local contact metamorphic deposits but, owing to its limited distribution, could not have accomplished the general metamorphism which we now see.

Syenite-Granite Complex

The next event of which we have definite knowledge was the intrusion of the syenite-granite complex. From the external structures

and internal textures of this mass, we may assume that it was intruded during a cycle of orogenic compression. The primary banding of the body is a feature which had its origin in the processes of differentiation during or preceding the process of intrusion, and represents variants of different composition which have been squeezed into elongated lenses by the compressive forces. As the magma consolidated, the growing crystals suspended in the liquid solution were given a parallel orientation by the currents within the magma. The directional influence given to these currents may have been due in part to the external compressive forces and in part to the thrust of the incoming magma itself against variously orientated blocks of the country rocks or Grenville formations. With progressive cooling, the increasing numbers and increasing growth of crystals ultimately resulted in mutual interference and the formation of a crystalline meshwork with liquid filling the interstices. Presumably the Diana portion of the complex arrived at this state of consolidation while the Croghan portion was still liquid. Within the Diana mass the minerals separating from the magma tended to form a constantly growing crystalline meshwork, which under the intense compressive stresses acting upon it tended equally to become a constantly failing meshwork. The crystals were ground against one another, broken, strained, granulated or pulverized, and the still liquid quartz was smeared out into long, narrow, flat leaves. That portion of the mass along the northwest received the stresses at their maximum and suffered crushing and pulverization to the highest degree. The crushing is of a coarser granular type as the Croghan granosyenite mass is approached, and ceases abruptly at the border of this mass, either because the stresses were partially dissipated and the strains relieved through the crushing of the Diana mass or because the Croghan mass was liquid. Within this Croghan mass, then, the lateral compressive forces served merely to produce an orientation, growth and segregation of the minerals along lines at right angles to the direction of compression but with boundaries due to intergrowth in the normal process of crystallization and not to crushing.

During the late stages of consolidation of the magma, satellitic dikes of hornblende syenite, hypersthene syenite, hyperite and granite and granosyenite were intruded along cracks resulting from the contraction caused by crystallization and cooling. They have undergone crushing similar in degree to that of their inclosing

country rock, and must have been intruded before the close of the period of consolidation and crushing of the complex.

The compressive forces continued subsequent to the complete consolidation of at least a part of the complex, since within a wide belt on the northwest, all the minerals, quartz included, are pulverized or granulated. The central and southeast belts are not thus affected, and the explanation may be either that the border band was the first to arrive at a stage of complete consolidation, or that the forces died out as they passed away from the border toward the southeast.

Joints. The directions of jointing within the syenitic masses fall, naturally, into four groups, whose limits are as follows: N 85° W—N 65° E, averaging N 85° E; N 20° W—N 50° W, averaging N 36° W; N 5° E—N 35° E, averaging N 20° E; and N 55° W—N 70°W, averaging N 62°W. There are scattering joints which do not fall within these groups. The first group, or approximately east-west joints, is by far the dominant one, occurring throughout all the syenitic masses irrespective of the direction of foliation. The second and third directions are about equally prominent, but both together are only slightly more common than the first group. The fourth group is the least prevalent.

Joints in igneous rocks are often ascribed to contraction due to cooling. Since it has been shown that the syenitic masses were under compression while cooling, it might be surmised that the tensile strains due to cooling would be relieved along shear planes induced by compression from without. Since the direction of the pressure was about N 45°W, the dominant joint direction is quartering to it, in accordance with the foregoing suggestion. The other groups are at various angles, which, however, is to be expected in view of the complexity of conditions.

Younger Granites

Some time after the period of diastrophism which witnessed the intrusion of the syenite, a renewed period of igneous activity set in. Batholiths of fine-grained granite, and sheets and large masses of coarse porphyritic granite were intruded into the Grenville.

None of these granite masses exhibits cataclastic textures, although the quartz sometimes shows strain shadows. Only the immediate borders of the larger masses are as much metamorphosed as the least mashed phases of the Diana syenite mass. They are therefore considered as belonging to a later period of intrusion than the syenite. Also, dikes of fine-grained granite, similar to the rock of

the Clark pond batholith, cut the granosyenite and syenite around its borders. The rock of the California batholith is similar both in character and in its structural relations to the Clark pond granite and is therefore considered of the same age.

The porphyritic granites present a more difficult problem when an attempt is made to prove their age by their field relations. The fine granites locally become of coarser grain through the influence of contact metamorphism, and dikes of the porphyritic granite are medium-grained; so that the two may grade towards each other in thin apophyses and render difficult or impossible the determination as to which rock a given medium-grained granite dike may represent.

The interrelations between the two granites is an unsolved problem. Despite the fact that masses of the two repeatedly occur close to each other, no positive evidence of intrusive relations has been found. Dikes of white or greenish granite, locally porphyritic, cut the pegmatitic gneisses in the Edwards area which are believed to be genetically associated with the fine-grained granites; but that there is any connection between these dikes and the porphyritic granites is not proved. Folding of the Grenville went on contemporaneously with the process of intrusion of the fine-grained granites; while the porphyritic granites seem to have come in along the bedding planes of the previously folded Grenville. Here again, however, the evidence is not convincing, and new data are necessary before the mutual relations of these two types of granite are known.

At the south end of the Geers Corners gabbro mass, veinlike dikes of medium-grained granite are found intruding syenite (plate 24, lower figure) which, in turn, is cutting the gabbro. The granite is believed to belong to the porphyritic bodies.

The porphyritic granitic and granosyenitic facies of the Diana syenitic mass may resemble the porphyritic granite, but they certainly do not belong to the same period of intrusion, since the former is always highly mashed and occurs only in the southeastern half of the quadrangle, while the latter is usually massive or slightly crushed and occurs only in the northwest half of the quadrangle.

The granites are thus younger than the syenite; but as to how much younger, there may be a difference of opinion. They may belong to essentially the same batholith as the syenite, intruded slightly later and during a decline in the cycle of orogenic movement, or they may belong to a much later, entirely separate, period of igneous activity. The granite of the Clark pond and California batholiths is similar, lithologically, to that called "Laurentian" by Cushing.

The term "batholith" has been used by many Canadian geologists (Adams and Barlow, 1910, 12) following Lawson, "to designate great lenticular shaped or rounded bosses of granite or gneiss, which are found arching up the overlying strata through which they penetrate, disintegrating the latter, and which possess a more or less distinct foliation, which is seen to conform in general to the strike of the invaded rocks when these latter have not been removed by denudation." This description fits to a nicety the California and Clark pond batholiths, especially the former. The map shows better than a description can how the rusty gneisses form a band completely surrounding the Clark pond batholith, with their strikes keeping parallel to its border.

Similarly the garnet gneiss sweeps around three sides of the California batholith and probably formerly extended completely around, although now cut out along a portion of the northwest side by a fault. Portions of the roof still remain on the surface around the borders of this granite dome and the synclinal basin of limestone and gneiss dividing the batholith into two parts is actually but a portion of its roof still preserved in a trough on its upper surface. The garnet gneiss on the northwest side of the batholith is thrown into a series of low open folds, with a prevailing dip of about 30° northwest. The same gneiss on the southeast side of the granite mass, except along the Lewisburg road where it is resting on the top of the underlying batholith, is vertical or steep west. At the northeast end of the batholith it is dipping 40°—45° northeast. This suggests the presence of a former asymmetrical anticline, or arch, consisting of garnet gneiss with a low dipping northwest limb, steep southeast limb and a northeast pitch which formed a cover or roof to the underlying dome, or core, of granite. The phenomena of the foliation of the granite conforming to the dip and strike of the gneiss, or vice versa, can best be explained by assuming that the folding of the gneiss and intrusion of the granite were contemporaneous.

The force came from the northwest, causing the granite to well up into the Grenville gneiss at a low angle, thereby pushing against the southeastern limb until it was vertical or even slightly overturned. The granite itself acquired in the process a foliation with a general low northwest dip, except in the immediate vicinity of the borders where it is parallel to the gneisses. At the same time thin sheets of granite were forced into the overlying formations, parallel to the bedding planes, constituting the East Antwerp and Kellogg Corners sills. It is hardly likely that these sills would have followed the

curving bedding planes if intruded at a later date, and they have not been folded into their present position while in a solid state, for they do not show evidences of the necessary attendant crushing. Hence it is necessary that we assume that their folding took place while they were still in a fluid, or partly fiuid, state. This is partly in line with Martin's conclusion with respect to the intrusion of a similar granite and the development of isoclinal folding in the Canton district. He states (1916, 29): "The granite was intruded previous to and probably also in large part during the period of folding."

The thin shell of contact metamorphic garnet rock, about a hundred feet thick, which incloses the batholith and formerly roofed it, has already been described.

It is amazing how all of the granites have included narrow bands of amphibolite or hypersthene gneiss which have in some way been preserved. The inclusions bear every resemblance in their form to dikes, and unless large exposures are seen, might be interpreted as such. Inclusions have been noted 50 feet long and 3 inches wide and 200 feet long and 2 feet wide. As a rule, however, they are fractured and crossed by pegmatite veins originating in the granite (plate 24, upper figure).

The Clark pond batholith evidently represents a more deeply eroded mass. The dips of the surrounding rocks are steep all the way around it, and a more thorough study is necessary to explain them. This mass, in contrast to the preceding one, has severely brecciated and broken up its surrounding belt of gneiss, sending off abundant dikes into it. There is no definite contact metamorphic band, nor is there any definite contact between gneiss and granite. The whole inclosing band of gneiss, a small area at the south end excepted, is pegmatitized and recrystallized, and constitutes a contact aureole.

In the Edwards area masses of fine-grained granite are intimately involved with Grenville gneiss as previously described but, as exposed, do not constitute a well-defined batholith.

The porphyritic granites present an entirely different mode of intrusion from the batholithic type of the fine-grained granites. The former are concordant intrusions, like the gabbro. They have come in along the bedding planes of the Grenville, often wedging them apart and assuming the form of lenses. In the band of garnet gneiss along the east side of the California batholith, narrow lenticular sheets of porphyritic granite have in many bands so thoroughly intruded the gneiss that it matters little whether the ensemble is mapped as granite with included sheets of gneiss, or as gneiss with intruded sheets

of granite. They form alternating bands, the result of layer intrusion along steeply dipping, foliated rocks. Brecciation is occasionally found, but is not common.

Pegmatites

Genetically associated with the younger granites, are pegmatite veins and dikes—the residual product from the crystallization of the granite magmas, and highly charged with "mineralizers." Since they are thus the last product of differentiation, they are found cutting the granites from which they sprang, as well as older rocks. Taken together, they form quite a considerable volume of material, as they have been injected into, and have permeated, nearly the whole of the Grenville rocks within this area. The result has been the igneous or contact metamorphism of these rocks on a regional scale. The only members of the Grenville which have escaped injection are the limestones and quartzites, although a considerable portion of the former has been altered to amphibolite by contact metamorphism. The hard, brittle amphibolite beds are cracked and torn apart. Almost every single one of these thousands of cracks in the amphibolites, no matter whether the latter are within the granite masses or the pegmatite gneiss, is filled with pegmatite. Only very rarely does the granite itself cross these fractures, unless the fragments have been displaced some distance. As Adams and Barlow have aptly said (1910, 141), "Pegmatite in fact is the universal healer of all wounds and dislocations in the various rocks of the area."

There are two ages of pegmatite veins, as evidenced by frequent cross-cutting relations, which may well be connected with the fine-grained and porphyritic granites, respectively. The veins are usually narrow; but veins up to several feet in width are common, cutting across the foliation. The latter are usually of a darker red color. Many of them carry an abundance of tourmaline which locally forms graphic intergrowths with quartz. In one dike such a tourmaline quartz rock forms a narrow three-inch border along each wall of a three-foot vein. From many of these dikes narrow veins can be traced, passing off into the gneiss and parallel to the foliation. These tourmaline-bearing veins have been found cutting both the fine-grained and the porphyritic granites. They are occasionally found cutting the syenites.

The Carroll School granosyenite is also cut by tourmaline-bearing pegmatite veins. Veins carrying magnetite, and one with plates of ilmenite several inches in diameter, are also found cutting this rock.

The pegmatite veins are usually coarse-grained, but the individual crystals rarely exceed a few inches in diameter. In one tourmaline bearing vein, about 1 mile southeast of Balmat Corners, however, feldspar crystals several feet in diameter were observed.

The intrusion of pegmatite veins is the last event in the Precambrian, evidence of which has been found in this quadrangle, although elsewhere in the Adirondacks diabase dikes of a later age are known.

Potsdam Sandstone

Previous to the deposition of the Potsdam, the Precambrian formations had been eroded and exposed to a considerable depth from beneath their thick, overlying cover. The present topography of the northwestern half of this quadrangle must resemble to a considerable extent the ancient surface of pre-Potsdam time, so recent has been the erosion of the Potsdam and the exposure of the underlying Precambrian rocks. In the valleys of this mildly rugged surface and upon the beveled edges of the tilted upturned Grenville beds, the deposits of clastic material accumulated locally, with a conglomerate bed at the base where it overlies resistant quartzite, but usually consisting of clean sands. It is probable that in course of time the deposits filled in the irregularities in the surface and, topping the divides, formed a thin, continuous blanket. Mere remnants of these rocks remain today, having been dissected and eroded during succeeding periods.

Pleistocene

The last great event recorded in this region was the glaciation of the country during the Pleistocene. But little seems to have been accomplished by the ice, at least during the last advance, in the way of erosion, since ponds such as Duck and Green ponds still retain their steep walls, the results of preglacial weathering of limestones. The harder rocks, however, where recently exposed, show a polished and striated surface, the striae usually oriented toward the true south. The ice dropped a thin continuous veneer of drift over the higher areas, and locally blocked the river channels during its waning stage and retreat so as to cause damming of the waters and impounding of lakes. Thus a sand and gravel plain is found along the middle branch of the Oswegatchie river, at an elevation somewhat over 880 feet.

Some terminal moraine material occurs near Harrisville, with a coarse apron of gravel to the south. Another sand plain extends along the Oswegatchie river and its tributaries, at an elevation of about

780 feet, and continues northward onto the Gouverneur sheet. Other gravel plains occur east of Natural Bridge. The rivers have for the most part cut through these beds of sand and gravel and are now engaged in eroding the rocks upon which they have been superimposed.

ECONOMIC GEOLOGY

Talc

A considerable deposit of talc occurs in the small limestone lens about 1⅜ miles northeast of Natural Bridge, where it is mined by the St Lawrence County Talc Company. The talc occurs as veins replacing the limestone and as a secondary alteration of some silicate mineral material disseminated through the limestone. Considerable serpentine is associated with it. The talc for the most part consists of a massive, fine-grained aggregate, quite unlike that of the Gouverneur belt.

A glacial bowlder of fibrous talc, 2 feet in diameter, occurs just south of Alpina. This bowlder may have been carried there from the Gouverneur district, but it is quite possible that it came from a source to the north, nearer at hand. The beds around Sylvia lake represent the continuation of the same belt which, to the northeast, carries the talc veins of the Gouverneur district. The limestone-quartzite rocks near Kinsman School are similar in character to the Sylvia lake beds and may represent the same formation. They carry many serpentinous beds, and have been prospected for talc. Serpentinous beds outcrop locally along the Oswegatchie river from Geers Corners northward, but glacial drift covers most of the rock.

Dolomite

Beds of dolomitic limestone at a point 3 miles north of Natural Bridge are being quarried to burn to magnesian lime. These beds belong to a formation similar to the Sylvia lake beds, and dolomitic beds may well occur in that area or its extension to the northeast.

Marble and Limestone

Marble was formerly quarried north of the railroad and west of the station at Harrisville, and has been described by Newland (1916, 193). The New York Lime Company formerly quarried limestone at a locality east of Natural Bridge for the manufacture of lime. The limestones are rarely free from igneous intrusions over any large area, that northeast of Pitcairn appearing to be most nearly so.

Mica

Small nests of phlogopite at contacts of igneous rocks with the limestones have been prospected at several places. Crystals up to several inches across occur in a small pocket of limestone on the border of a fine-grained granite mass at the west end of Lake Bonaparte behind a little pond two-fifths of a mile south of Mud lake. Similar pockets may occur elsewhere along the border of this mass.

Biotite occurs occasionally in large plates in coarse pegmatite veins, but nowhere was seen in sufficient quantity to warrant exploitation.

Hematite

Small veins of massive crystalline hematite, locally associated with reddish quartz or ordinary quartz, are occasionally found in the limestones. The largest vein seen was about 2 feet wide and was exposed for 20 feet at the level of the Oswegatchie river, about 1¼ miles south of the northern border of the quadrangle, at the conspicuous projecting point in the river. Other localities where veins were observed are: along the southwest side of the granite boss north of Toothaker brook, three-fourths of a mile north of Bullhead pond, and on the south side of the trail 1 mile west of Geers Corners.

Zinc Blende

Deposits of zinc blende, which occur in the limestone belt from Sylvia lake northeast to Edwards, have been recently described by Newland (1916, 623–44). In addition to these, a local dissemination of pyrite and zinc blende occurs in a serpentinized limestone on the bank of the Oswegatchie river about seven-eighths of a mile south of the northern border of the quadrangle, at the eastern bend of the river. A prospect pit, about 10 feet in diameter and 20 feet deep, has been opened on the vein, which is a zone parallel to the bedding of the limestone, from a few inches to 2 feet wide, with disseminated ore. There are also a few little pockets and veinlets of crystalline hematite in the limestone. Small disseminations of galena and zinc blende have also been reported from the vicinity of Lake Bonaparte.

Road Metal

The hornblende and augite syenites, especially the more basic phases, are well adapted for use as a road metal, as are also the more massive portions of the gabbros. The Grenville limestone may be used to advantage where the traffic does not require so tough and heavy a rock.

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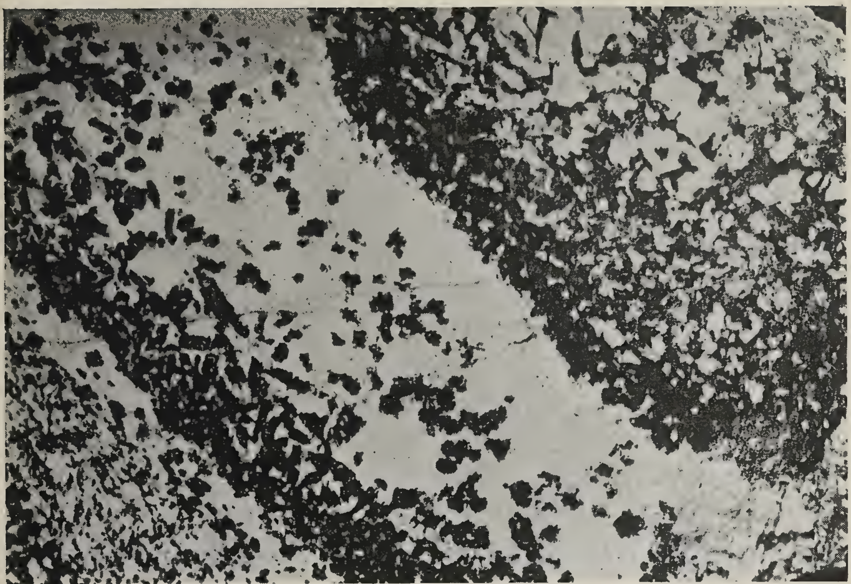
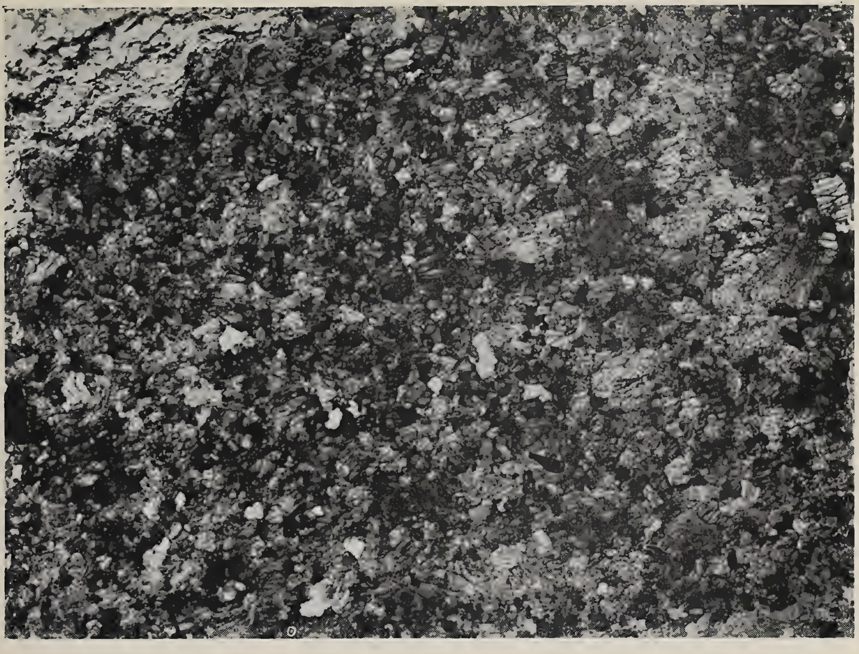


Upper figure Gabbro gneiss with primary gneissic banding of feldspathic and pyroxenic character. Natural size.

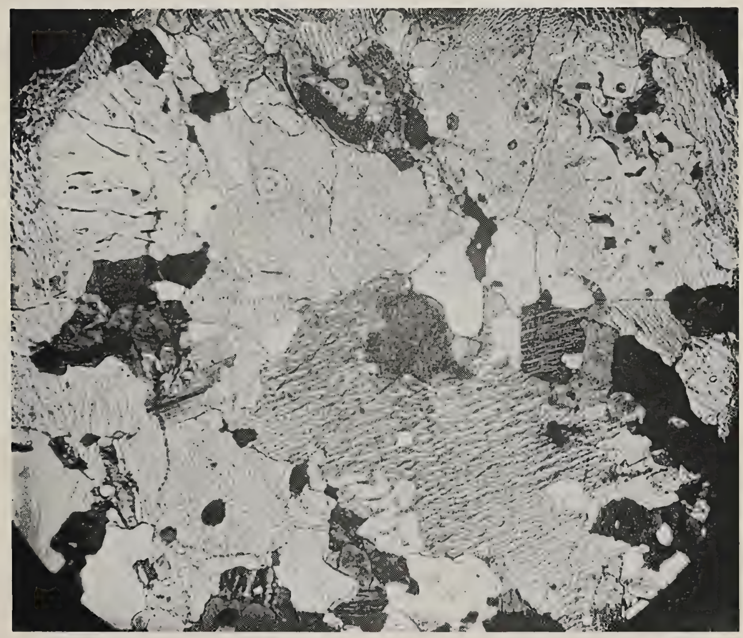
Lower figure Photomicrograph of above, crossed nicols, x17 diameters.



Upper figure Normal massive equigranular augite syenite, from contact with Grenville limestones. Preserved from crushing by more easily recrystallizing limestone. Natural size. From northwest belt of metamorphism.

Lower figure Photomicrograph of above, showing primary interlocking texture of crystallization. Crossed nicols, x17 diameters.

Plate 3



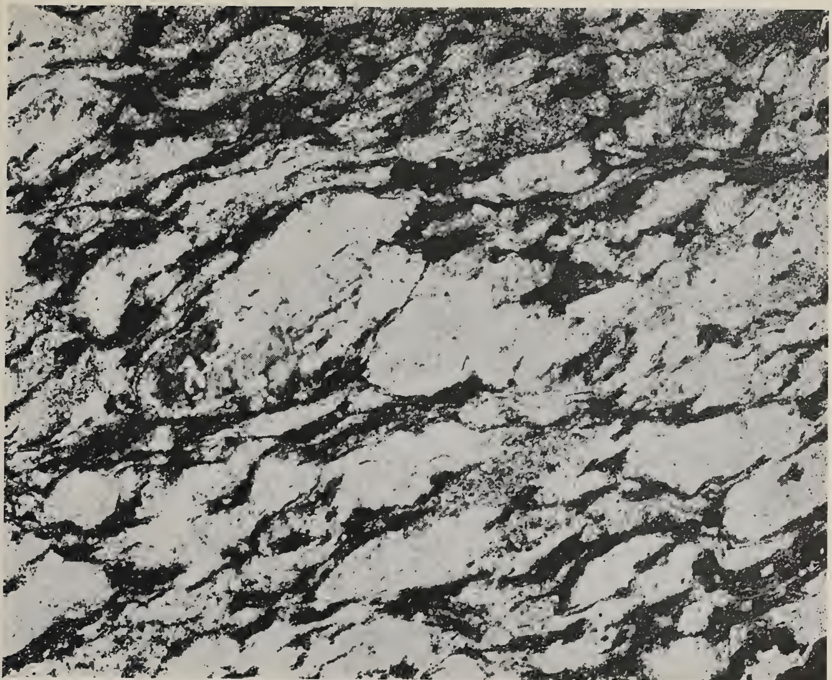
Upper figure Hornblende syenite gneiss. From Croghan mass and southeast belt of metamorphism. Natural size. Compare with upper figure, plate 2.

Lower figure Photomicrograph of above, showing interlocking texture of crystallization and absence of crushing. Compare with lower figure, plate 2. Crossed nicols, x17 diameters.

Plate 4

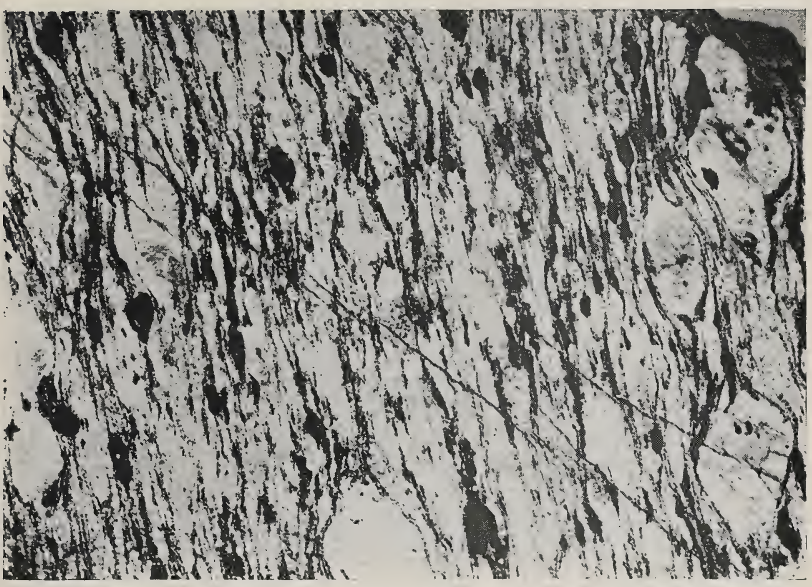
Upper figure Hornblende-biotite grano-syenite gneiss. Natural size. From Croghan mass and southeast belt of metamorphism.

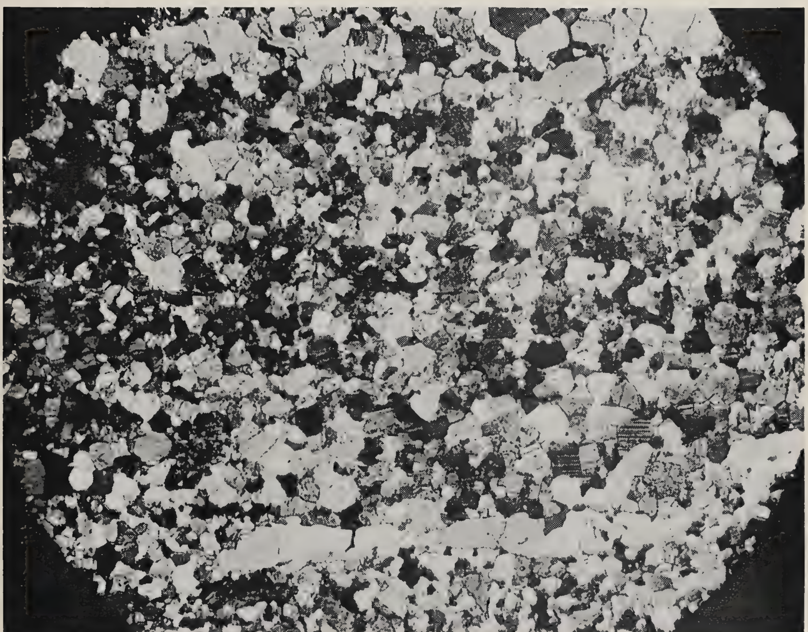
Lower figure Photomicrograph of above, showing interlocking texture of crystallization. Crossed nicols, x17 diameters.



Upper figure Hornblende syenite gneiss. Augen gneiss with protoclastic texture. From the Diana mass and central belt of metamorphism. Natural size.

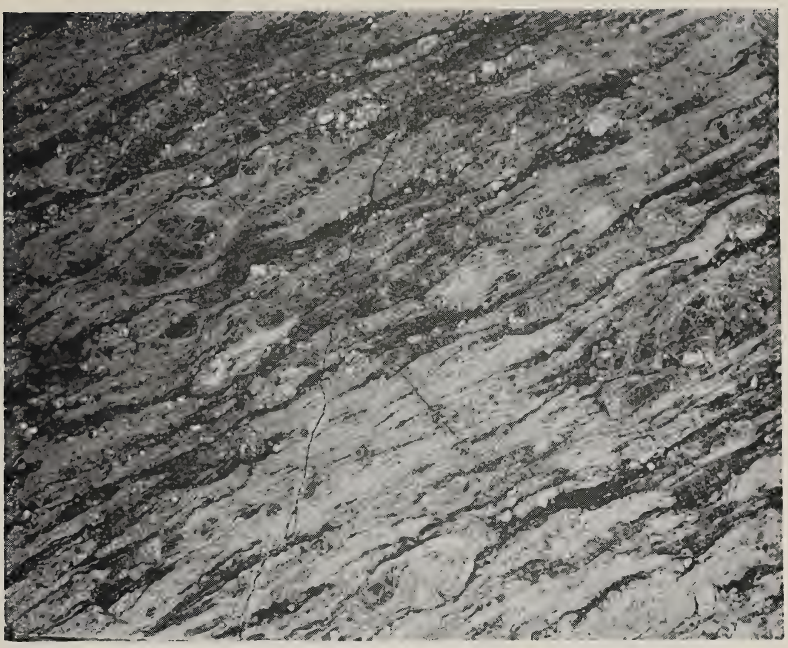
Lower figure Photomicrograph of above; quartz in massive uncrushed leaves, other minerals partly or completely granulated; protoclastic texture. Crossed nicols, x17 diameters.

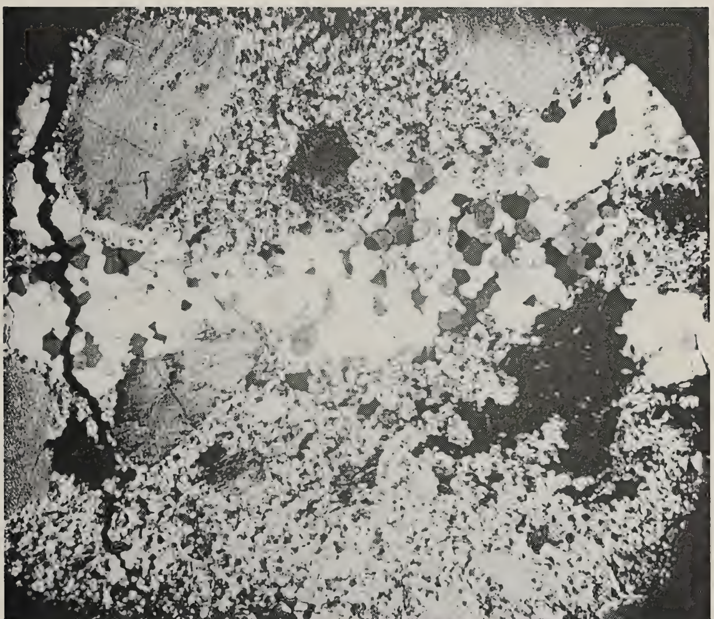




Upper figure Hornblende syenite gneiss. Augen gneiss in advanced stage of granulation. From Diana mass and central belt of metamorphism.
Lower figure Photomicrograph of above. Crossed nicols, x17 diameters.

Plate 7

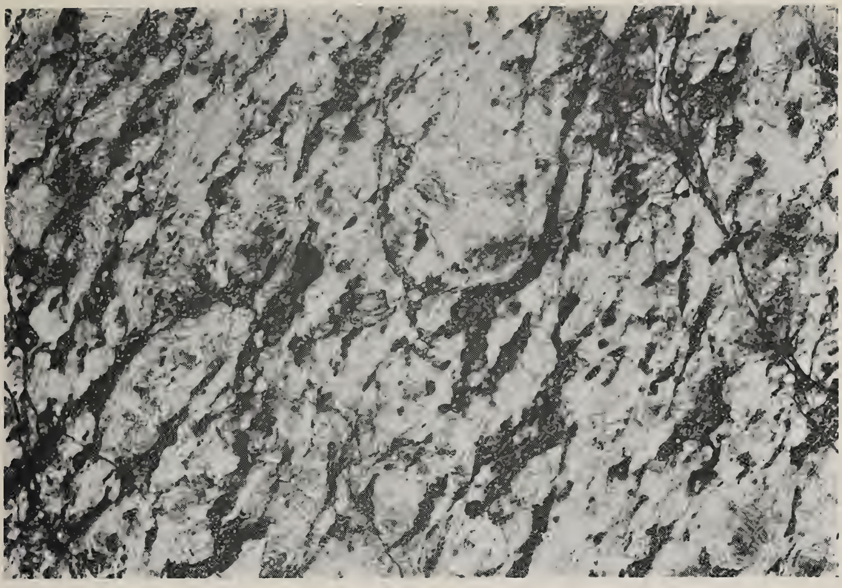


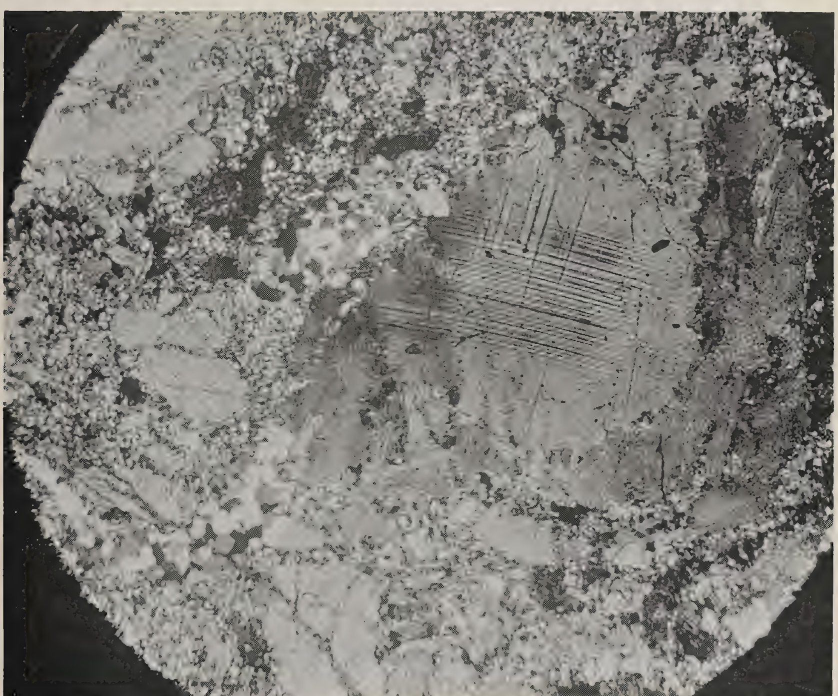


Upper figure Hornblende granosyenite gneiss. Augen gneiss with cataclastic-protoclastic texture. From the Diana mass and northwest belt of metamorphism. Natural size.

Lower figure Photomicrograph of above, showing cataclastic-protoclastic texture; quartz granulated, other minerals partly or completely pulverized. Crossed nicols, x17 diameters.

Plate 8

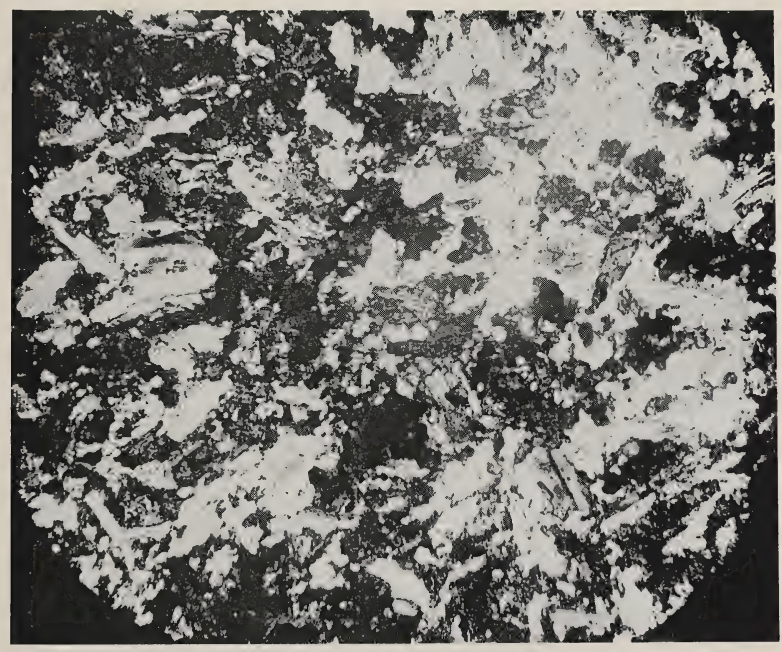




Upper figure Augite syenite gneiss. Augen gneiss with cataclastic-protoclastic texture. From the Diana mass and northwest belt of metamorphism.

Lower figure Photomicrograph of above, showing cataclastic-protoclastic texture. Quartz is granulated, other minerals partly or completely pulverized. Phenocryst of feldspar with core of plagioclase surrounded by zone of microperthite, pulverized along fractures. Crossed nicols, x17 diameters.

Plate 9

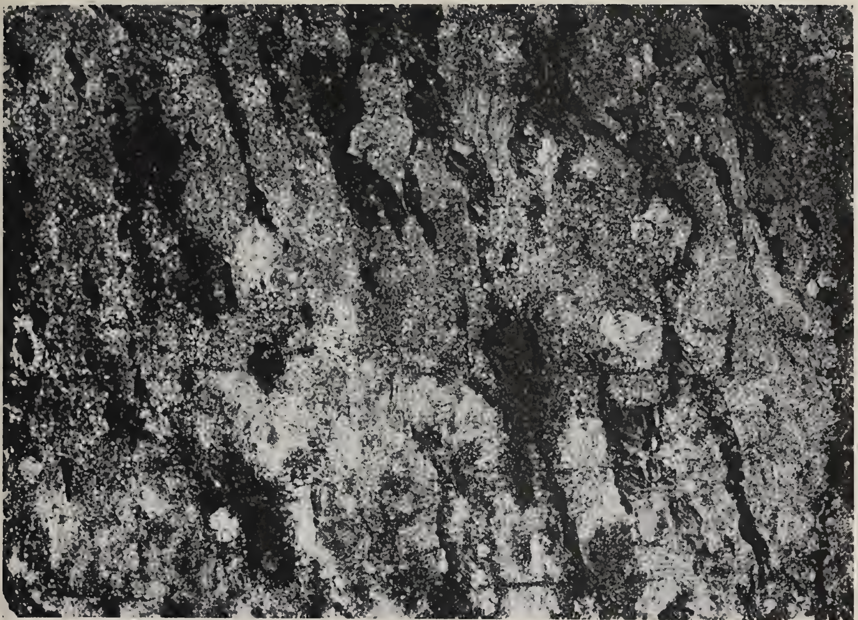


Upper figure Porphyritic basic augite syenite gneiss, showing parallel orientation of phenocrysts. Note phenocryst below hammer handle showing basin-like character as result of differential weathering. From locality west of Natural Bridge.

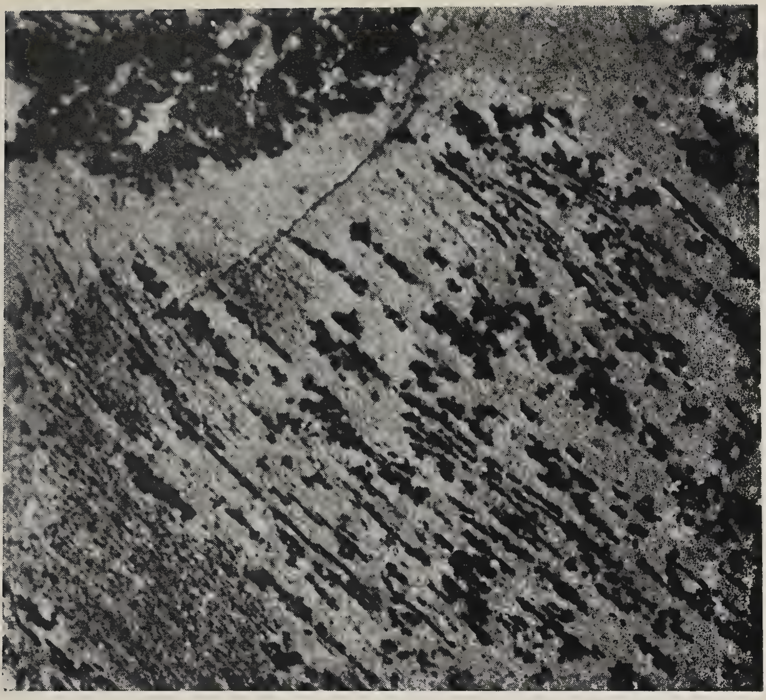
Lower figure Photomicrograph of thin section of hyperite from dike in limestone, partly preserved from crushing by easily recrystallizing character of limestones. Near Natural Bridge. Crossed nicols, x17 diameters.

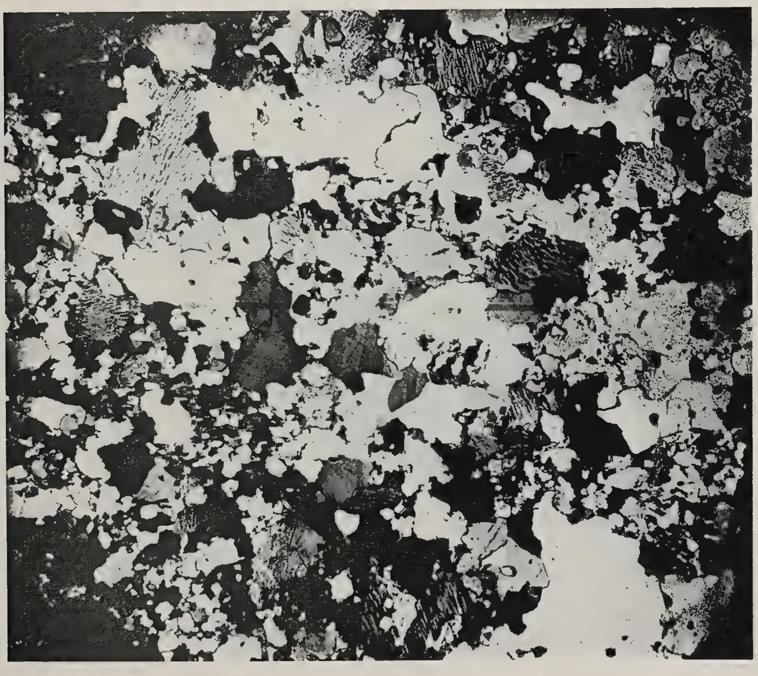
Upper figure Photomicrograph of thin section of hyperite dike, showing interlocking texture of crystallization. From Croghan mass and southeast belt of metamorphism. Crossed nicols, x17 diameters.

Lower figure Photomicrograph of thin section of hyperite dike in Diana mass, showing cataclastic texture and partial or complete pulverization of minerals. From northwest belt of metamorphism. Crossed nicols, x17 diameters.



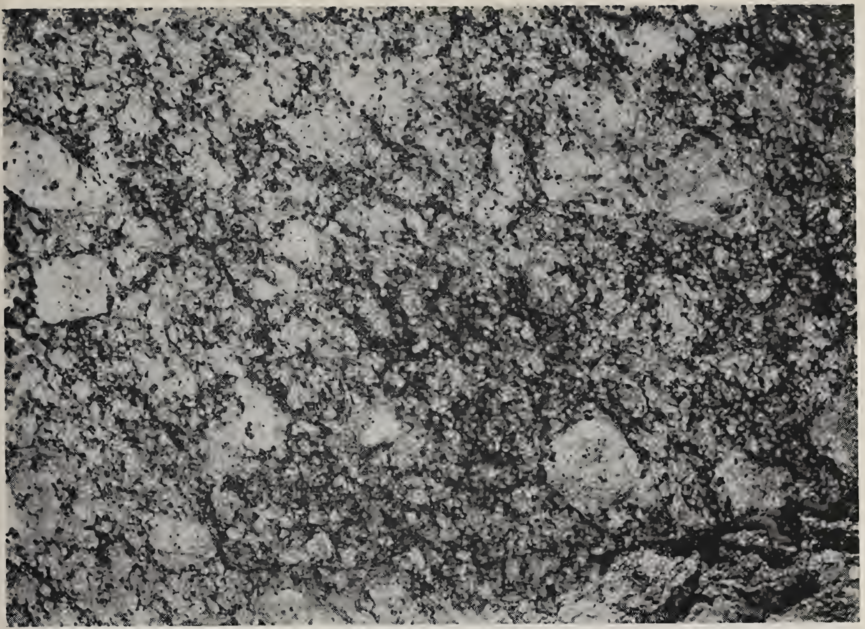
Upper figure Granite gneiss from sheet intrusive into hornblende syenite gneiss. Protoclastic texture, central belt of metamorphism. Natural size.
Lower figure Photomicrograph of above, showing protoclastic texture; quartz massive, other minerals granulated. Crossed nicols, x17 diameters.

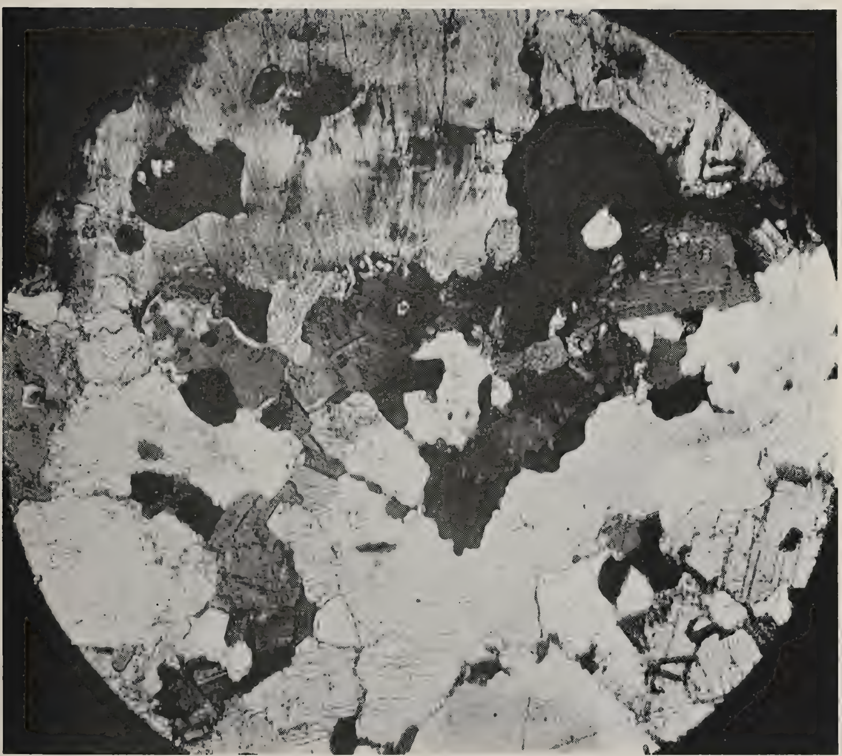




Upper figure Cordierite gneiss. Relic gneiss formed by intrusion and partial reaction of granite with fragment of Grenville gneiss. Black mineral is cordierite. From eastern border of Clark pond granite batholith. Natural size.

Lower figure Photomicrograph of thin section of granite gneiss from California batholith. Primary flow gneiss with interlocking texture of crystallization. Crossed nicols, x17 diameters.





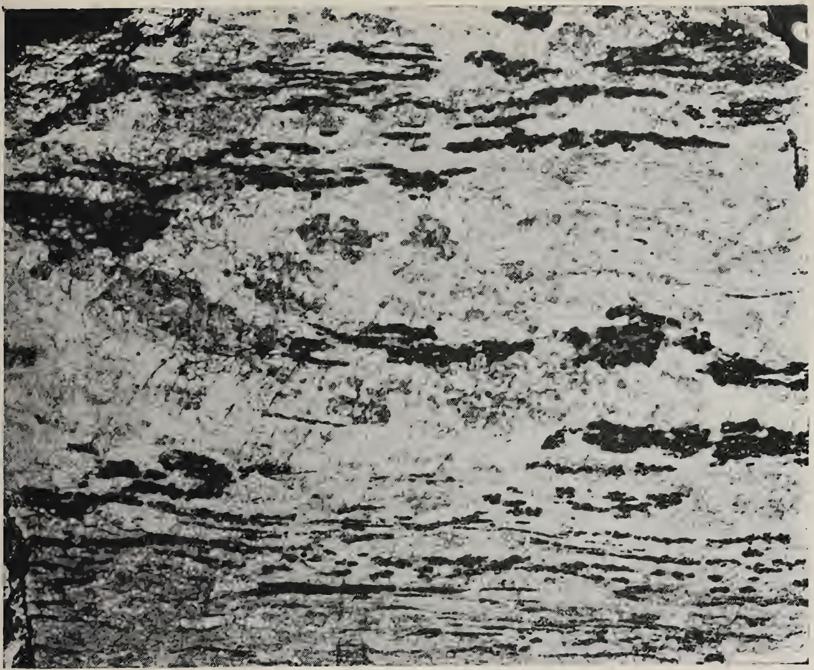
Upper figure Porphyritic granite gneiss. From core of mass north of Pitcairn. Primary flow gneiss with no evidences of crushing. Natural size.

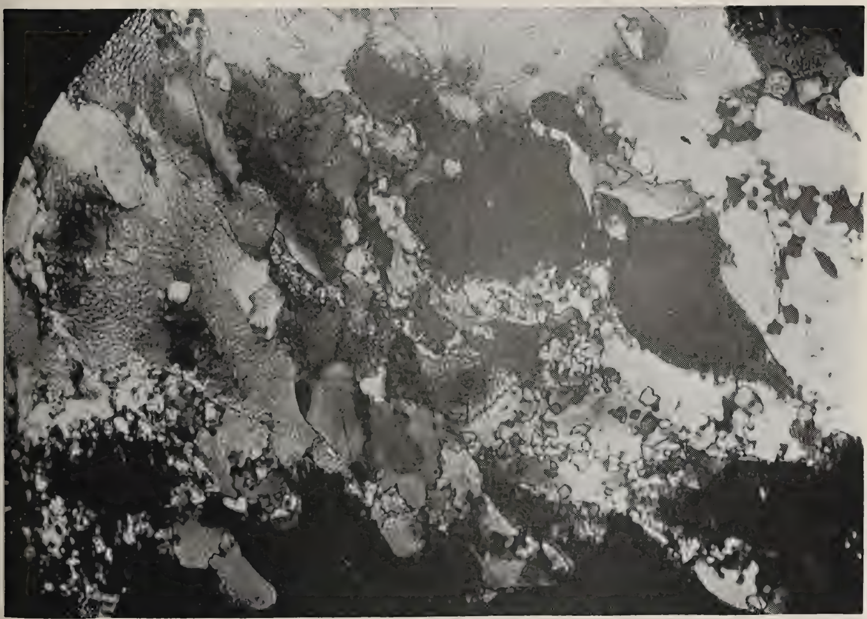
Lower figure Photomicrograph of above, showing primary interlocking texture of crystallization. Crossed nicols, x17 diameters.

Plate 14

Upper figure Granite gneiss. From western border of mass north of Geers Corners. Primary flow gneiss with protoclastic texture. Natural size.

Lower figure. Photomicrograph of above, showing protoclastic texture; quartz in massive leaves, other minerals granulated. Crossed nicols, x17 diameters.

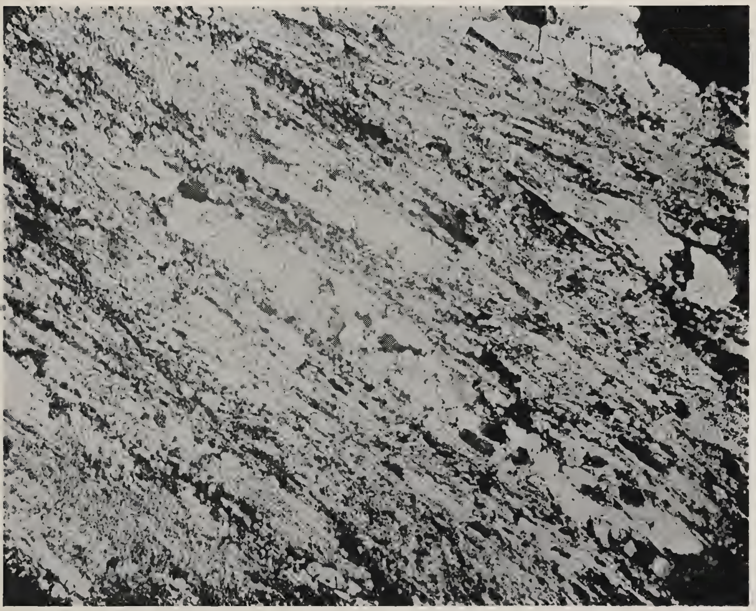




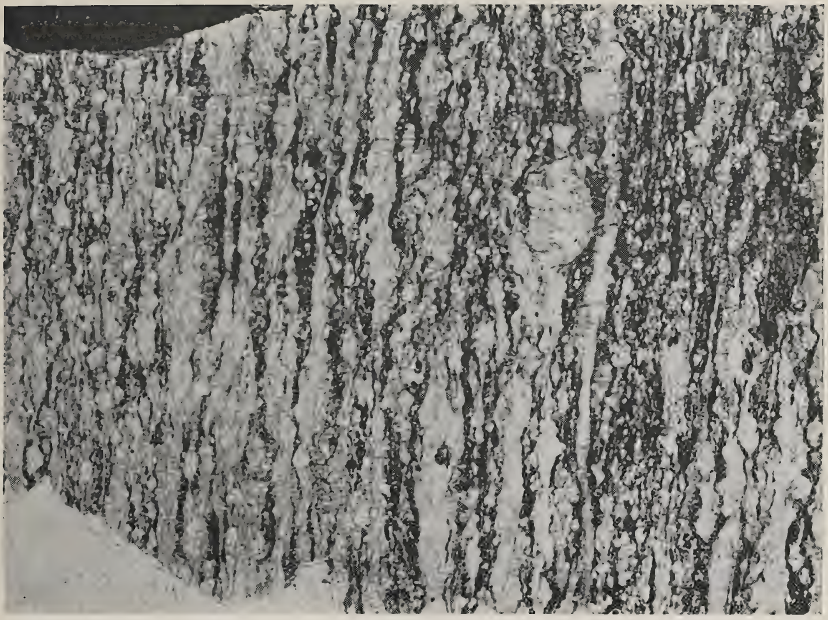
Upper figure Cordierite-garnet gneiss. Pegmatitized and recrystallized portion of Grenville formation. From northern end of Clark pond granite batholith. Black mineral is cordierite. Natural size.

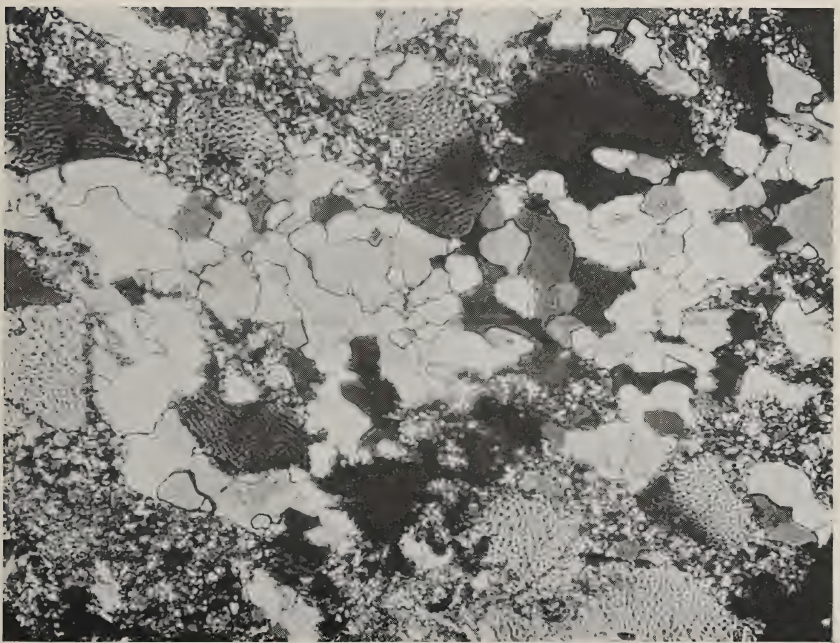
Lower figure Photomicrograph of above, showing sutured structure in quartz resulting from recrystallization as result of contact metamorphism. Crossed nicols, x17 diameters.

Plate 16



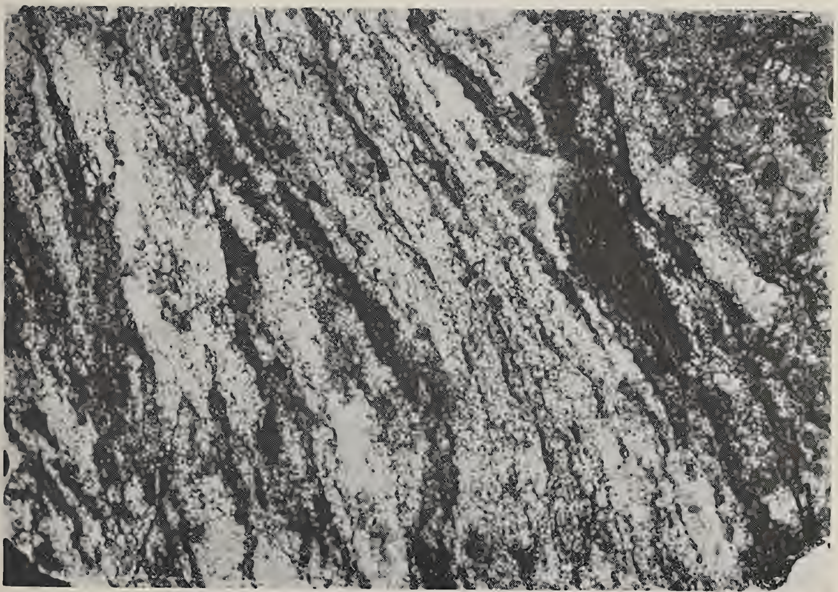
Upper figure Quartz-sillimanite gneiss. Natural size. Portion of Grenville formation recrystallized by Clark pond granite batholith. Natural size.
Lower figure Photomicrograph of above. Crossed nicols, x17 diameters.





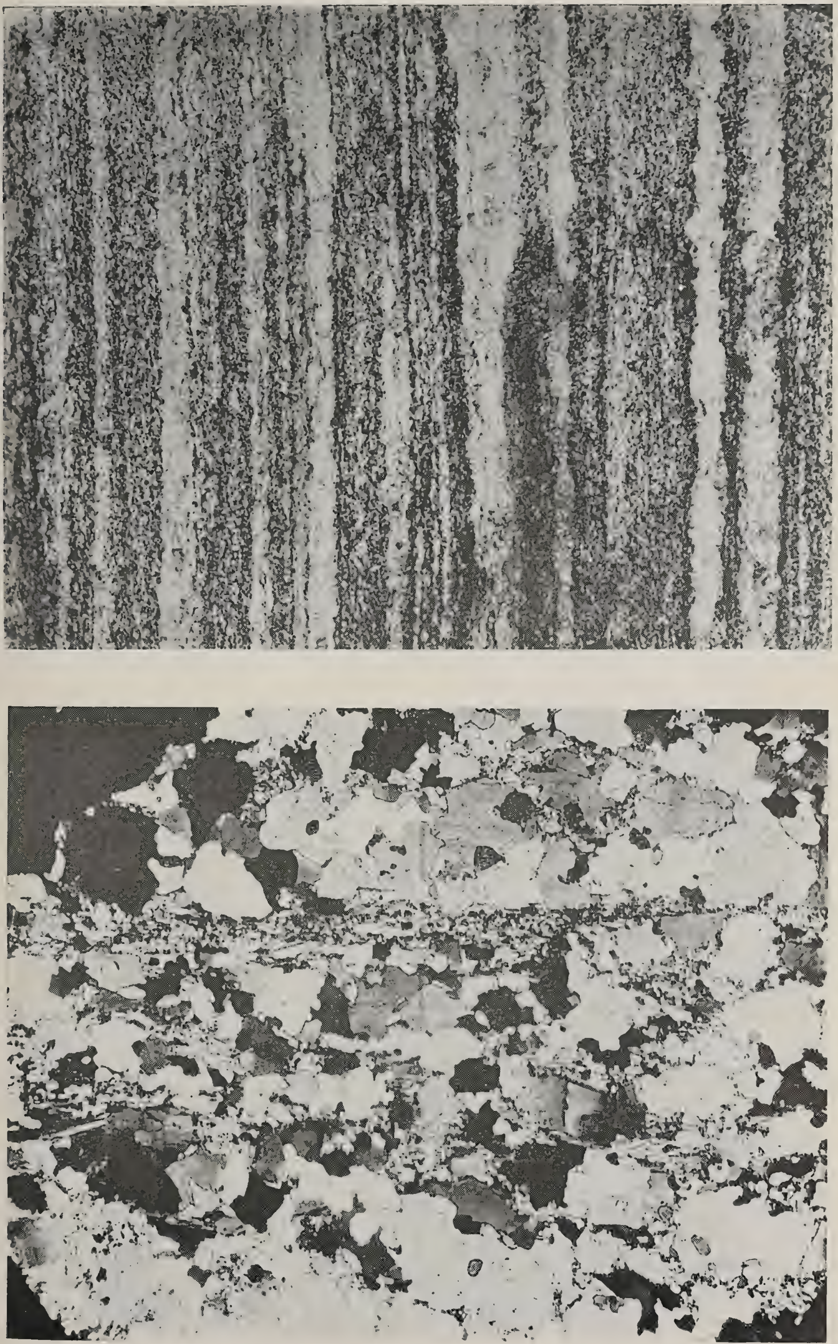
Upper figure Syenitic relic gneiss. Shreds of Grenville gneiss (dark colored) between lenticles of syenite gneiss (light colored). Natural size.
Lower figure Photomicrograph of above showing cataclastic texture. Northwest belt of metamorphism. Crossed nicols, x17 diameters.

Plate 18



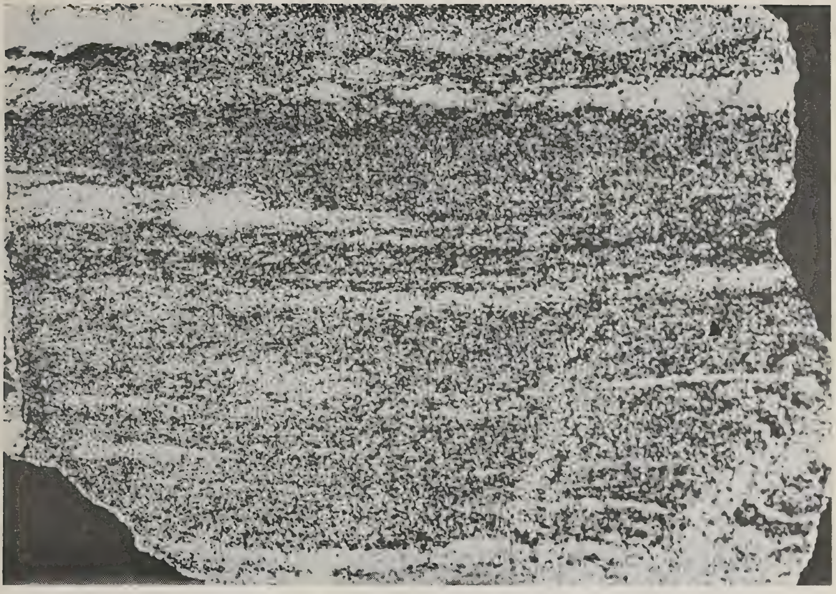
Upper figure Grenville garnet-biotite gneiss. Band of garnet (dark colored) and rare pegmatite vein (light colored, with garnets). Natural size. Shows early stage in process of pegmatitic injection.

Lower figure Injection gneiss. Sillimanite-biotite gneiss of Grenville formation (dark colored) shredded and disintegrated by injection with, and permeation by, pegmatitic material (light colored). Natural size.



Upper figure Relic gneiss. Relics of biotite-garnet Grenville gneiss (dark colored), almost completely disappearing in multitude of granitic pegmatite veins (light colored). Natural size. Eastern border of California batholith. Lower figure Photomicrograph of above. Crossed nicols, x17 diameters.

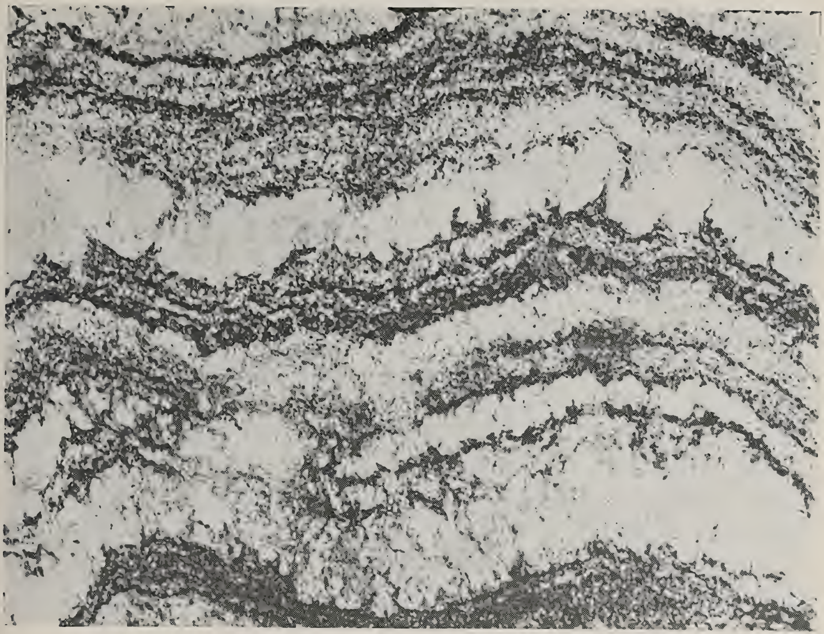
Plate 20



Upper figure Grenville gneiss in last stage of disintegration by pegmatite veins and granitic juices. Natural size.

Lower figure Photomicrograph of above. Note the essentially homogeneous character in contrast to preceding gneisses. Crossed nicols, x17 diameters.

Plate 21



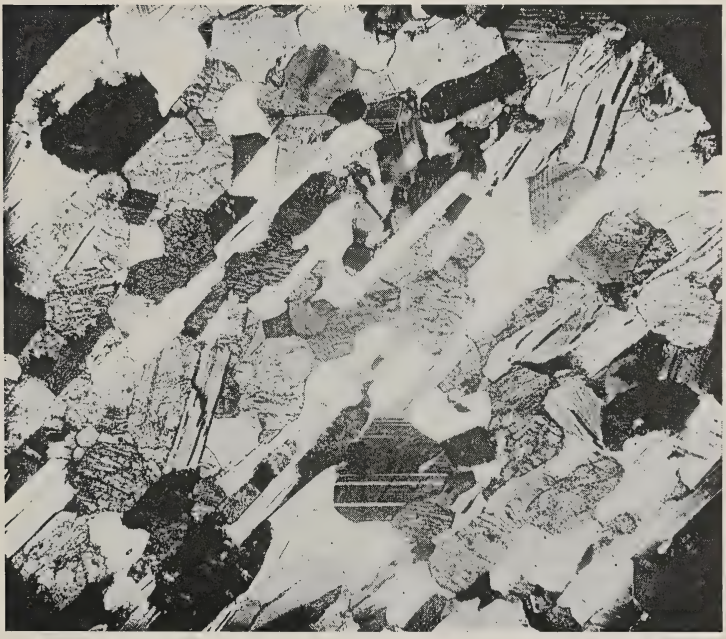
Upper figure Palimpsest structure in pegmatitized Grenville gneiss. Biotite is oriented parallel to banding, quartz and feldspar of pegmatite veins at right angles. Locality northwest of Lake Bonaparte. Natural size.

Lower figure Same specimen as above, etched with HF and H_2SO_4 and coated with NH_4Cl. Shows orientation of pegmatite minerals at right angles to banding. Quartz is in relief.

Plate 22

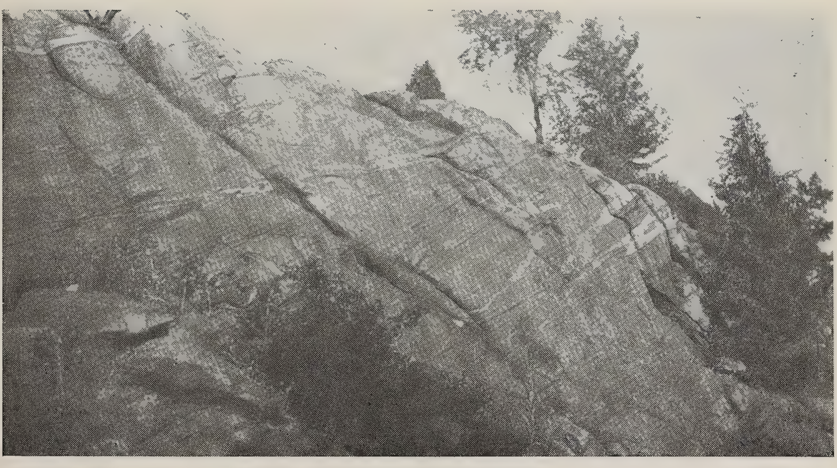
Upper figure Hypersthene gneiss injected by syenite. North side of Lake Bonaparte. Syenite veins weather in relief.

Lower figure Grenville biotite-garnet gneiss so thoroughly softened by the multitude of injected pegmatite veins as to show flowage structure around disrupted fragments of amphibolite (dark colored).



Upper figure Inclusions of amphibolite in grano-syenite. Near Tinney's Corners.

Lower figure Photomicrograph of amphibolite. Crossed nicols, x17 diameters.



Upper figure Inclusion of amphibolite in granite. Amphibolite broken and crossed by granite and pegmatite veins.

Lower figure Syenite gneiss intruded by sheets of granite.

INDEX

New York State Museum Bulletin

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New York State Museum

GEOLOGY OF NEWBURGH AND VICINITY

BY

F. HOLZWASSER

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The Front Face of the Shawangunk Mountains

View taken looking north from Millbrook mountain. The nearly vertical cliff in the foreground is cut on the resistant west-dipping Shawangunk conglomerate. The break in slope in the middle distance marks the boundary between the Shawangunk conglomerate and the Hudson River slate. Talus from the conglomerate covers the slates below the cliff. At the base of the mountains in the distance is seen the gentle slope, transition to the nearly level surface of the Wallkill valley, and at the top, the gentle back slope of the mountain, in which is seen the notch in which lies Lake Mohonk.

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GEOLOGY OF NEWBURGH AND VICINITY

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INTRODUCTION

Those who travel up the Hudson river can scarcely fail to note the sudden change in the character of the landscape at the northern boundary of the Highlands, from rugged mountains to relatively low open country. Not all, however, recognize that the underlying cause is geologic and that the great contrast is due in large part to one of geology's most intelligible laws, namely, that hard rocks resist erosion best and stand high long after soft rocks have been worn down to lowlands.

The area included within the Newburgh quadrangle, the geology of which is the subject of this bulletin, lies almost wholly in the low rolling country north of the highlands of the Hudson, where comparatively weak slates and sandstones constitute the underlying rocks. Because of the generally low relief, no difficulty is experienced in traversing the ground, although a serious hindrance to successful geologic mapping is found in the cover of glacial drift which throughout most of the area conceals the bedrock.

Acknowledgements

Grateful acknowledgement is here made to Dr Rudolf Ruedemann, State Paleontologist, for kindly advice and cooperation, and to the members of the staff of the department of geology of Columbia University, with whom the various phases of the work have been discussed. The writer wishes to express her appreciation of all the generous assistance and helpful suggestions given by Professor C. P. Berkey.

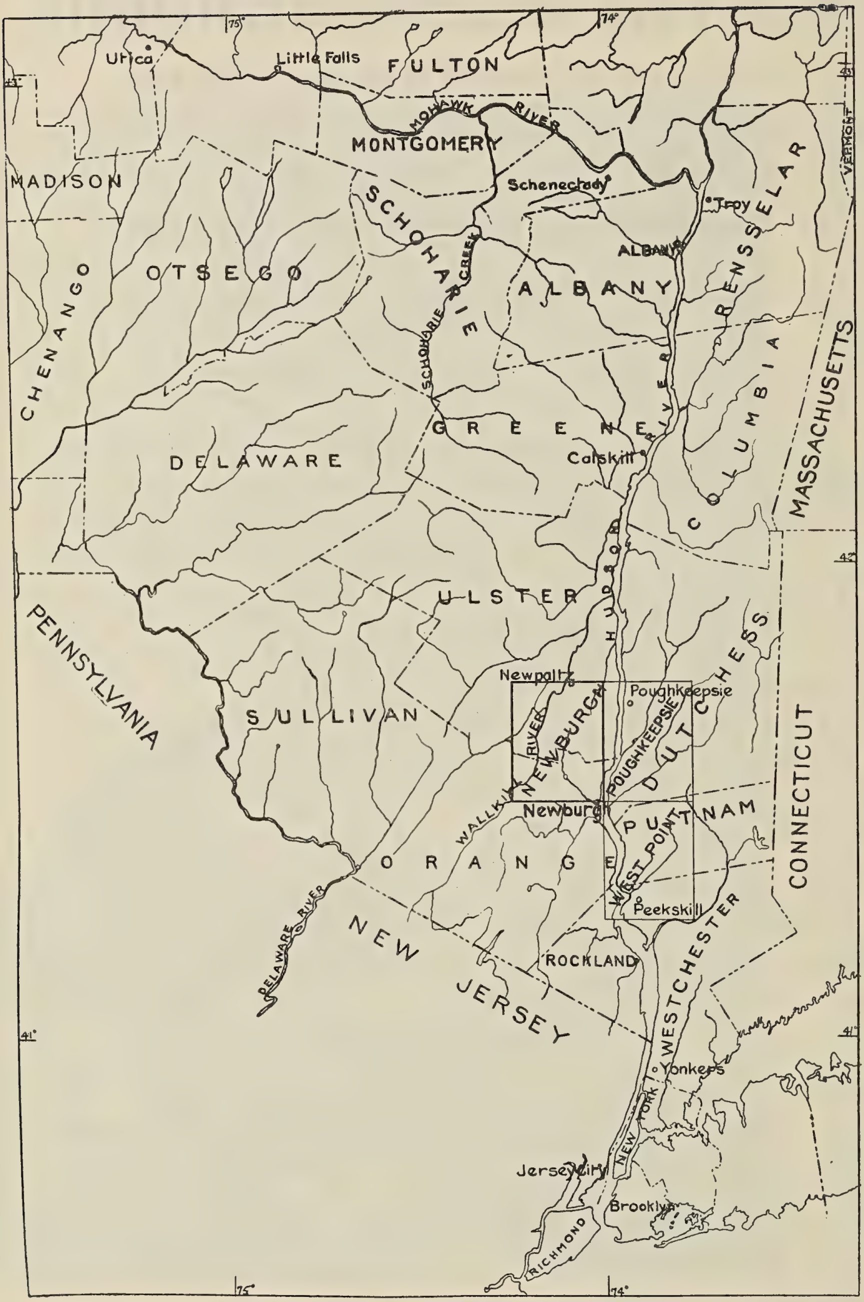


Figure 1. Location map showing the position and the boundaries of the Newburgh quadrangle

Location

The Newburgh quadrangle comprises a territory of 225 square miles in southeastern New York on the west side of the Hudson river about halfway between New York City and Albany. From north to south the sheet covers 17.3 miles, and 13 miles from east to west. The southern two-fifths of the area lie in Orange county, the remaining three-fifths in Ulster county.

Newburgh, situated in the extreme southeast corner of the quadrangle, 55 miles north of New York City, has 30,000 inhabitants and is by far the largest center of population and industry in the region. Among the larger villages are New Paltz, Wallkill, Walden and Montgomery, all of which lie along the Wallkill river which flows through the center of the area from south to north. The greater number of villages and farms can be reached only by private conveyance, owing to the lack of adequate railway facilities.

Historical Sketch

The region ranks high in interest for the layman on account of its intimate connection with the early history of our country. When the first refugees from the Old World reached the coast of northeastern North America, they found open to them two main gateways into the interior. Those who landed at the north sailed up the St Lawrence river; those who touched shore farther south advanced by way of the Hudson river. To their progress inland there were countless obstacles—the greatest, no doubt, being the hostility of the Indians and the great physical obstruction formed by high forbidding uplands. To those pursuing the southern route, the Highlands of the Hudson were the first important barrier; but when they had passed this obstacle, there stretched before them, to west, north and east, many thousand square miles of low, gently rolling hills, well-watered and productive.

Over this area the Indians were masters, and they resented forcefully any intrusion into their domain. Notwithstanding their enmity, the exiles hastened to settle the attractive region. Records[1] tell of the founding of a small Huguenot community as early as 1677, on the site of New Paltz (where now a delightful little museum commemorates these early settlers), whither these exiles had fled in escaping the Indians. Somewhat later, in 1708, a few relig-

[1]Bacon, E. M. The Hudson River from Ocean to Source. N. Y. 1902.
Skeel, A. Historic Towns of the Middle States. 1899.
Lossing, B. T. The Hudson from the Wilderness to the Sea. N. Y. 1866.

ious exiles from the Lower Palatinate on the Rhine succeeded in reaching the site of the present city of Newburgh. Queen Anne of England had given them patent to this land, but they were unable to survive the rigorous hardships of their "upland" home. By 1747 they had abandoned the struggle and had given way to the descendants of the early English, Scotch and Huguenot settlers. Gradually these hamlets grew in size, and other small communities were founded as more and more of the flat land was occupied. Those along the main rivers were not only started first, but also grew fastest and have maintained their advantage to this day, so that the large centers of population in the quadrangle lie along the Hudson and Wallkill rivers.

During the Revolutionary War there was much activity in the central portion of the Hudson valley. Although no battles were fought nearer than Stony Point and Forts Clinton and Montgomery, yet its geographic position gave Newburgh such strategic importance that it was necessary to keep large numbers of troops there throughout the war. Washington himself made his headquarters in the vicinity for several years, since the ferry at Newburgh was the key to domination of the whole sector. With that ferry in their possession, the British could have cut off the New England states and thereby so greatly have weakened the forces of the Continental Army that the outcome of the war might have been reversed. For a year after cessation of actual fighting, Washington made his headquarters in the city of Newburgh, living from March 1782 until April 10, 1783, when the army was disbanded, in the Hasbrouck House. This handsome old structure is still standing in a lovely park overlooking the Hudson river and houses many mementos of its stirring associations.

In general, it may be said that the points of historical interest lie in the lower lands of the quadrangle; the seeker after natural beauty must, on the other hand, go to the higher portions. A spot famed for its natural setting is Lake Minnewaska, situated on the crest of the Shawangunk mountains, which lie along the western margin of the district. If there is anything more beautiful than the lake, cliffs and steep-walled valleys, it is the distant view from the mountain. Northeast, east and southeast across the quadrangle, the vista is of cultivated fields and forested hills bordered by mountains. Along the eastern margin of the quadrangle are the Marlboro mountains, lower than the Shawangunks, and supporting one of New York's richest berry and fruit communities. A very picturesque

sight, indeed, are the fine homes built in among the rows of fruit trees or in the midst of raspberry and currant fields.

Important Earlier Work

The study of the geology of North America may well be said to have had an early start in New York State. Even before the establishment of the state survey in 1836, observations in a broad way had been recorded. Although no specific reference was made to the Newburgh area in any of the very early scientific writings, the territory adjacent to the Hudson river was never omitted. Among the earliest references to the geology of this region is one appearing in print in 1817, by William Maclure[2], who noted a broad valley extending on both sides of the Hudson river and "consisting principally of graywacke, slate and limestone." At about the same time Amos Eaton published some more general observations on the geology of eastern North America and included notes on the valley of the Hudson. In 1820[3] he wrote of the "graywacke region between the Hudson and the Susquehanna," while in his textbook[4] he discussed among the formations and localities of his Transition Series the clay slate forming the bed and banks of the Hudson river and the Millstone Grit of the "Shawangunk Mountains."

The foundation for all subsequent observations and deductions on the geology of this region was the careful work of W. W. Mather, State Geologist of the First District in the early work of the New York State Geological Survey. "The first district comprised all the easternmost counties of the State from Washington southward—an area of 12,263 square miles."[5] With such an extensive area to cover and with comparatively little assistance, Mather accomplished a monumental work. Van Hise[6] pays him this tribute, "while in his great New York Report of 1843 there are some crude notions, the comprehensive general results announced accord to a remarkable degree with the views held by the best informed of the geologists who are working in the field today." This report[7], the final one on the first district, brings together and summarizes all Mather's previous observations, which had been published in a series

[2]Maclure, William. Observations on the Geology of the United States of America. 1817. p. 97.

[3]Eaton, Amos. An Index to the Geology of the Northern States. 1820.

[4]Eaton, Amos. Geological Text-Book. Albany. 1830.

[5]Merrill, G. P. Contributions to a History of American State Geological and Natural History Surveys. Bul. 109, U. S. Nat. Mus. 1920. p. 328.

[6]Van Hise, C. R. Correlation Papers, Archaean and Algonkian. U. S. G. S. Bul. 86. 1892. p. 415.

[7]Mather, W. W. Natural History of New York: Geology, part I. 1843.

of five annual reports appearing from 1837 to 1841 inclusive. The first detailed account of the geology of Orange county was the work of W. Horton[8], and it was incorporated in Mather's final report[9].

In 1848 appeared a geographical history of the State,[10] which includes also a discussion of the geology as known at that time. An intimate review of the early development of Orange county was published in 1862 by Denniston,[11] who besides being a descendant of one of the county's earliest settlers, lived there himself. His discussion of the geology and general conditions of the district is a summary of work already accomplished rather than the result of any special investigation of his own.

The literature of the next 15 years or more is barren of additional work on the Newburgh district. In the last quarter of the nineteenth century, however, much work was carried on by Dwight,[12] Dana,[13] and others in Dutchess and Westchester counties, and often they extended their observations across to the west side of the Hudson river. During this period A. A. Julien[14] also studied the glaciation of the Shawangunk mountains, and N. H. Darton[15] pub-

[8]Horton, W. State of New York, No. 275, In Assembly, 1839. Appendix B to the Third Geological Report of the First District. p. 134-75.

[9]*Loc. cit.*

[10]Brockett, L. P. & Mather, J. H. A Geographical History of the State of New York. 1848.

[11]Denniston. New York State Agricultural Society, Trans., 1862. p. 135-235.

[12]Dwight, W. B. Fossils of Wappinger Valley Limestone. Amer. Jour. Sci. 17:389-92. 1879.

Recent Explorations in the Wappinger Valley Limestone of Dutchess County, N. Y. Amer. Jour. Sci. 19:50-54, 451-53, 1880.

Further discoveries of Fossils in the Wappinger Valley or Barnegat Limestone. Amer. Jour. Sci. 21:78-79. 1881.

Report of Progress in Geological Investigation in the Vicinity of Poughkeepsie. Trans. Vassar Bros., Inst. v. I, pt. 1, 1881-83. p. 141-52.

Recent Investigations and Paleontological Discoveries in the Wappinger Limestone of Dutchess and Neighboring Counties, N. Y. State. Abstract Am. Ass'n Adv. Sci. Proc. 31:384-87. 1883.

Fossils of the Wappinger Valley. Amer. Jour. Sci., Ser. 3, 27:249-59. 1884.

Recent Explorations in the Wappinger Valley Limestone of Dutchess County, N. Y., Amer. Jour. Sci., Ser. 3, 34:27-32. 1887.

[13]Dana, J. D. Geological Relations of the Limestone Belts of Westchester County. Amer. Jour. Sci. Ser. 3, 33:450-56. 1880.

On the Hudson River Age of the Taconic Schists. Amer. Jour. Sci., ser. 3, 17:61-64, 375-89. 1879.

[14]Julien, A. A. Notes on the Glaciation of the Shawangunk Mountain, N. Y. Trans. N. Y. Acad. Sci. III, 1883. p. 22-30.

[15]Darton, N. H. Preliminary Report on the Geology of Ulster Co., N. Y. State Mus. Rep't 47. 1894. p. 485-600.

Geology of the Mohawk Valley in Herkimer, Fulton, Montgomery and Saratoga Counties. N. Y. State Mus. Rep't 47. 1894. p. 601-24.

Report on the Relations of the Helderberg Limestones and Associated Formations in Eastern New York. N. Y. State Mus. Rep't 47. 1894. p. 383, 422.

lished reports on the geology of eastern New York, especially on Ulster county. The slate belt extending through Vermont and eastern New York was carefully studied in the field and described by T. N. Dale.[16] Toward the end of the nineteenth century H. Ries[17] published the most detailed account yet given of the geology of Orange county. This report and Darton's Geology of Ulster County referred to above, have been most drawn upon for information in this paper. The more recent works dealing with this area include W. J. Miller's Geological History of New York State[18] and C. P. Berkey's[19] Geology of the New York City Aqueduct.

From this brief summary of the literature dealing with the region under consideration it can be seen that comparatively little detailed work has been done in the Newburgh area. Earlier investigators leaned rather heavily on the work of the first survey, and their contributions added only minor points of restricted application. The work of Darton and Ries covered areas which were too large to permit the treatment of local details. Correlation of the dark slaty shales and sandstones of Middle Ordovician age which cover such extensive areas of the Newburgh sheet, has been successfully undertaken by Dr Rudolf Ruedemann,[20] whose work on these formations extends back some 20 years, but has not involved any detailed studies in the Newburgh district, while C. E. Gordon's bulletin[21] on the Poughkeepsie quadrangle adjacent to Newburgh on the east, adds much to our knowledge of the Newburgh district itself, by comparison with the same formations which on the east side of the Hudson river are more extensively exposed.

Shawangunk Mountain, National Geographic Magazine. March 1894. 4:23–34.

[16]Dale, T. N. State Belt of Eastern New York and Vermont. U. S. G. S. 19th Ann. Rep't, pt. III. 1897. p. 159.

Geology of the Hudson Valley, U. S. G. S. Bul. 242. 1904. p. 7–57.

[17]Ries. Report on the Geology of Orange County, N. Y. State Mus. 49th Ann. Rep't, pt. II. 1895. p. 395–477.

[18]Miller, W. J. Geological History of New York State. N. Y. State Mus. Bul. 168. 1914.

[19]Berkey, C. P. Geology of the New York City (Catskill) Aqueduct. N. Y. State Mus. Bul. 146. 1911.

[20]Ruedemann, Rudolf. Hudson River Beds near Albany and Their Taxonomic Equivalents. N. Y. State Mus. Bul. 42. 1901.

The Lower Siluric Shales of the Mohawk Valley. N. Y. State Mus. Bul. 162. 1912.

Geology of Saratoga Springs and Vicinity. N. Y. State Mus. Bul. 169. 1914.

[21]Gordon, C. E. Geology of the Poughkeepsie Quadrangle. N. Y. State Mus. Bul. 148. 1911.

CORRELATION TABLE

Era	Period	Epoch	Newburgh	Equivalents in New York and New Jersey	Diastrophic movements
Psychozoic			Alluvium	Alluvium	
Cenozoic	Quarternary	Pleistocene	Drift	Drift	
	Tertiary		Absent		
Mesozoic			Absent		Palisadian disturbance
Paleozoic	Permian		Absent		Appalachian revolution
	Pennsylvanian		Absent		
	Mississippian		Absent		
	Devonian		Absent		
	Silurian	Monroan	Absent		
		Salinan	High Falls shale (immediately to west)	Longwood shale	
		Niagaran	Shawangunk conglomerate	Medina sandstone and Shawangunk conglomerate	
	Ordovician	Cincinnatian	Absent		Taconic disturbance
		Utica Trenton Black River Chazyan Chazy	Hudson River formation Balmville limestone and Wappinger limestone	Utica Trenton { Schenectady shale, Canajoharie shale, Snake Hill shale, Glens Falls limestone } Martinsburg shale Jacksonburg limestone Rysedorph Hill conglomerate Amsterdam limestone	Slight orogeny St Peter break
		Beekmantownian	Wappinger limestone	Probably present; Kittatinny limestone	
	Cambrian	Croixian	Wappinger limestone	Hoyt limestone Theresa formation Potsdam sandstone; Kittatinny limestone	
		Acadian	Absent		
		Waucoban	Wappinger limestone Poughquag quartzite	Poughquag quartzite; Hardyston sandstone	

Precambrian	Laurentian		Granitic intrusions Dioritic intrusions	Storm King granite Pochuck gneiss (igneous part)	Laurentian revolution
	Grenville		Grenville sediments (much modified)	Pochuck gneiss (sedimentary part)	
	Keewatin		Absent	Probably some greenstones and amphibolites of the Adirondacks	

GENERAL GEOLOGY

Geological Formations

From a glance at the geologic map of the Newburgh quadrangle it will be seen that the geology is relatively simple. Only five formations, as far as we know, have any influence on the surface forms of the area, but they represent such a small portion of geologic time as to make us realize that very little of the history of the region is evident from a quick study of the map. Especially is this true since the significance and correlation of these five units is not as well understood, even after prolonged study, as are other formations of New York State. In fact, each of the formations represented on the map is and has been the subject of much controversy, both as to age and conditions of origin. The more detailed discussions of these complicated problems will be found in the technical treatment of the geology in succeeding pages.

Although only five formations representing a mere fraction of geologic time have been recognized in this area, still of these five, one is among the oldest of which we have record in eastern North America and one is among the latest.

The Precambrian. If we consider these units chronologically, from as near the beginning as our knowledge of these inconceivably remote times will allow, we must start with the old crystalline schists which are the foundation of Cronomer hill, and which also appear as the low, narrow, northward extension of Snake hill, lying just off the Newburgh sheet southeastward from Cronomer hill. These very old much metamorphosed and much injected rocks are detached masses of the main body which constitutes the Highlands of the Hudson, and which extends on both sides of the Hudson river south of this area. By comparison with the rocks of the Highlands and the other ancient crystallines of New York, such as those of the Adirondacks, the age is determined to be Grenville, modified by later Precambrian intrusions.

The Cambro-Ordovician series. Next in age, and lying with distinct unconformity on the Grenville rocks, is a massive, well-cemented quartzite, which in this area gives no clue for an exact age determination. By reason of similar stratigraphic position and lithologic character, it is correlated with the Poughquag quartzite of Dutchess county, where it has been found to contain a Lower Cambrian fauna. The Poughquag has a very limited extent in the Newburgh quadrangle; it outcrops only along a narrow belt trending southwest from the eastern base of Cronomer hill. Conformably

on this quartzite lies a thick, compact gray limestone, known as the Wappinger limestone, which has been determined in other areas to represent some portion of the time from Lower Cambrian through Lower Ordovician. In this area fossils were found in the limestone to indicate two horizons only, Upper Cambrian and Middle Ordovician. So much of the bed rock is covered by surficial deposits, however, that it can not be claimed that these two are the only horizons represented in the limestone, which by analogy with similar limestone in the adjoining Poughkeepsie quadrangle is postulated also to be of Lower Cambrian and of Lower Ordovician age.

Similar doubt exists as to the exact age of the next overlying formation, a series of slaty shales and sandstones, which are locally and commonly known as the Hudson River group and to which the name was originally applied. Although this is the bedrock over most of the area, covering probably 9 times the space occupied by all the others together, so uniform is the drift cover, that outcrops occur only on hills and in artificial cuts. From the fossil content, which is scanty and rather uniformly distributed, the horizon of this mass of slate and sandstone is considered to be Middle Ordovician, and is correlated with the Snake Hill formation.

The Shawangunk conglomerate. The only other bedrock in the whole area is that forming the Shawangunk mountains, which cut across the northwestern corner of the quadrangle. Here again a very specialized and sparse fauna (no fossils at all were discovered in the work done for this bulletin) makes correlation and age determination very difficult. From studies made on the continuation of this formation to the north, south and west, however, it is thought likely that the Shawangunk conglomerate is Lower Silurian in age.

The glacial drift. Over all these formations irrespective of any consideration except topography, lie unconsolidated gravels, sands and silts of glacial origin. These were deposited by the continental ice sheet, which during the Pleistocene period covered eastern North America as far south as the Ohio river.

Major Structural Features

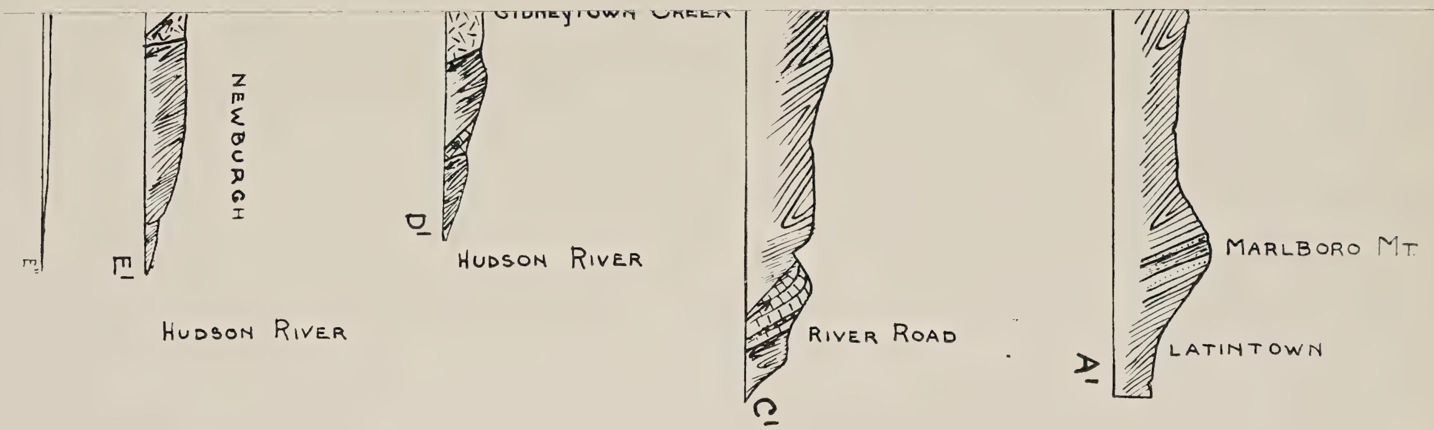
Introduction. The general principle holds true in geology that the older the geologic series the more likely is the structure to be complex. The principle follows from the fact that the older the series the greater the probability that it has passed through more than one period of marked deformation of the earth's crust.

Of the formations in the region around Newburgh, the glacial drift alone is younger than the Middle Paleozoic. Therefore, with the exception of the unconsolidated surficial cover, the rocks of the district are very ancient, and have existed through many periods in which the growing earth has reached the limit of its resistance and has buckled under the stresses accumulated within it. Some of the adjustments due to the resulting strains are visible now at the surface, since erosion has removed the overlying rocks and exposed structures which were formed at considerable depth.

By the correlation of deformations in more or less widely separated areas in the eastern United States, definite mountain-making epochs are believed to be established. The effects of several of these periods of disturbance are recognizable in the territory under study. To be sure it is difficult, and in many cases practically impossible, to assign a certain structural feature to a particular time. Especially is this true in the study of a rather limited area, and an area of ancient rocks which show the end effects of successive deformations, the later ones superposed on, and more or less masking, the earlier ones. Even the more obscure structures may be solved, however, when all the details are carefully considered and when the structural lines are followed into immediately adjacent areas where the relations are less doubtful or less involved.

The most striking of these structural adjustments are the folds and faults which constitute one of the three major elements in the configuration of the surface as we see it today—the other two being the kind of rock concerned and the almost universal drift cover.

Folding. The folding, which is so prominent a feature of the structure belongs to the type known as close isoclinal folding, and is, no doubt, the composite result of at least three periods of deformation. The first of these did not affect the rocks directly, for it took place in Precambrian time, long before any of the formations in the quadrangle, except the ancient Grenville sediments, had been deposited. It is impossible to evaluate in detail the influence of this early disturbance on the structure today; but it seems reasonable to assume that these very ancient rocks may be considered the



MARLBORO MT
LATINTOWN
A'
RIVER ROAD
C'
GIDNEYTOWN CREEK
HUDSON RIVER
D'
NEWBURGH
HUDSON RIVER
E'
E"

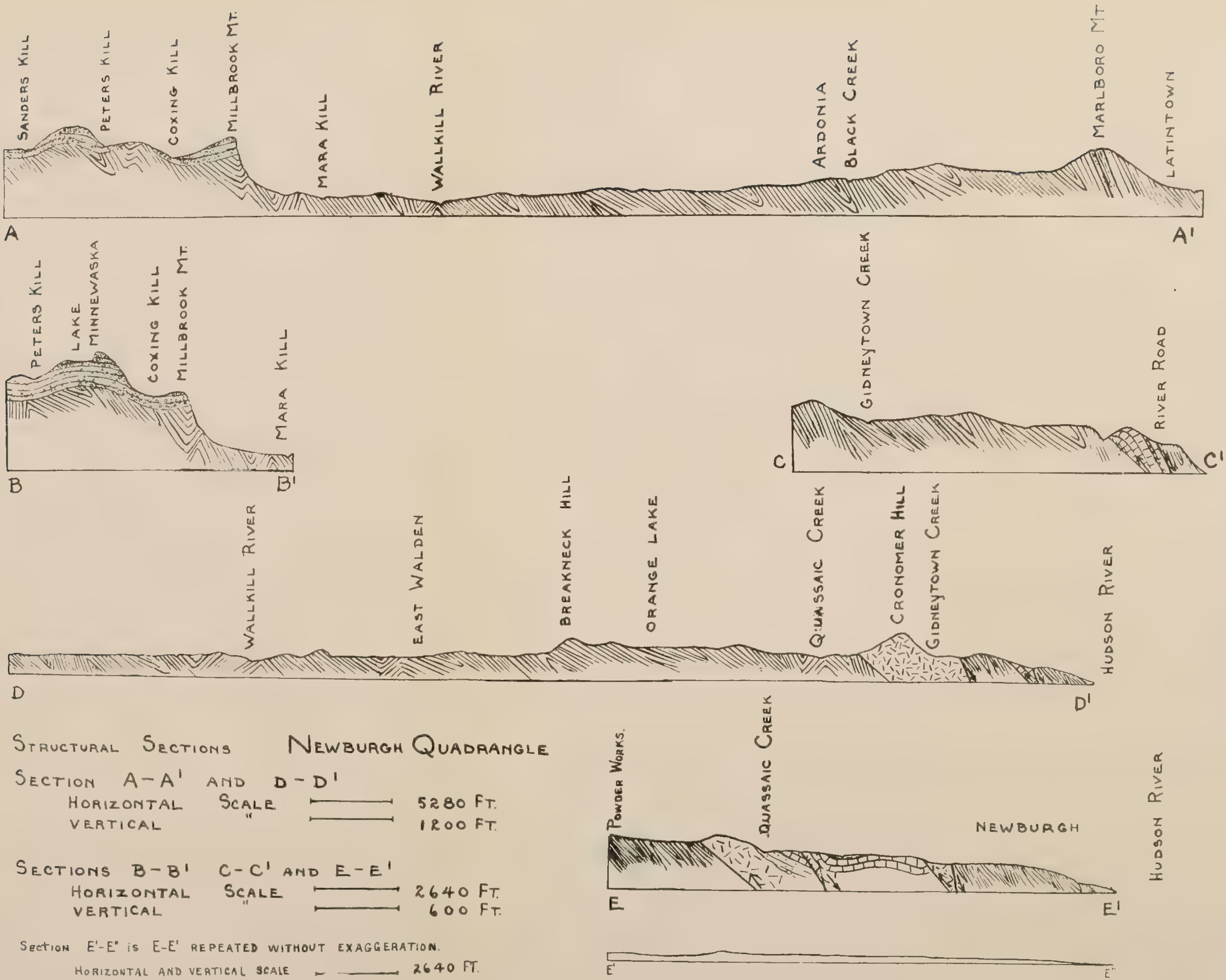

Sanders Kill
Peters Kill
Coxing Kill
Millbrook Mt.
Mara Kill
Wallkill River
Ardonia
Black Creek
Marlboro Mt
Latintown
A
A'
Peters Kill
Lake Minnewaska
Coxing Kill
Millbrook Mt.
Mara Kill
B
B'
Gidneytown Creek
River Road
C
C'
Wallkill River
East Walden
Breakneck Hill
Orange Lake
Quassaic Creek
Cronomer Hill
Gidneytown Creek
Hudson River
D
D'
Structural Sections Newburgh Quadrangle
Section A-A' and D-D'
Horizontal Scale 5280 Ft.
Vertical " 1200 Ft.
Sections B-B' C-C' and E-E'
Horizontal Scale 2640 Ft.
Vertical " 600 Ft.
Section E'-E" is E-E' repeated without exaggeration.
Horizontal and vertical scale 2640 Ft.
Powder Works.
Quassaic Creek
Newburgh
Hudson River
E
E'
E'
E"

Figure 2

foundation upon which the later formations were built, and that in spite of their very limited representation at the surface today, they exist not so far below the surface in much greater extent and have controlled to some degree the trend of subsequent formations and deformations.

The next folding is connected with the Taconic disturbance of the later Ordovician. Although no detailed study has been made in order to figure out accurately the characteristics of this folding in the Hudson valley, and although it could not be determined from the observations made within the Newburgh quadrangle, the region is known to have suffered deformation at that time; for to both north and south where there are exposed contacts between the rocks concerned in the disturbance (the Cambro-Ordovician formations with the Hudson River formation at the top) and those that were deposited after the period of folding (the Silurian rocks with the Shawangunk at the base) the relationship is that of an angular unconformity. The contact between the Hudson River and the Shawangunk formations is visible at Rosendale to the north and at Otisville to the south. It is probable that the Taconic uplift influenced a much greater area than is ascribed to it, for the unconformity between the Ordovician shale and the Silurian conglomerate is seen as far south as Schuylkill Gap, Pa.

To the long continued movements that culminated in the Appalachian revolution closing the Paleozoic era, may be attributed the dominating influence in determining the character of the folds of the area. The characteristics of the Appalachian folding are relatively well understood, and are recognized in the northeast-southwest trend of the close folds overturned toward the west. This disturbance impressed itself so strongly on the structure that it has masked to a large extent the results of preceding deformation.

This discussion applies to the whole geologic series exposed in the quadrangle, although the formations of Cambro-Ordovician age exhibit the folding more typically than do the others. The Grenville rocks are so compressed and injected that no definite folding is discernible; the rocks of age later than the Taconic disturbance were naturally not affected by any but the Appalachian folding.

Faulting. The faulting in the area may also be attributed to three periods of diastrophism. Evidences of faulting preceding the Cambrian are very obscure, although a detailed study of the old Precambrian rocks has brought some to light. Faults resulting from the Taconic disturbance have not been noted, but from a considera-

tion of the probable physical conditions existing at the time it is thought that the pre-Taconic rocks were faulted, and have since been healed so thoroughly that now they present no physical weaknesses. Displacements originating in the Appalachian revolution are recognized in the faults which accompanied the folding, and which may be in part gravity, in part thrust faults, although the overthrusting from the southeast must be taken as particularly characteristic of this period of deformation. Many of these faults have been healed, yet less thoroughly and firmly than those of earlier origin. Still another age of displacement is the Triassic, the epoch of the major disturbances in the Highlands of the Hudson and surrounding regions. Tilting no doubt accompanied this faulting, which is especially of the block fault type, but folding of this age has not been noted except in the drag effects associated with the faulting.

Unconformities. Perhaps the most reliable evidence of different ages of disturbances in a region is to be found in the angular unconformities between beds. If a series of gently folded strata overlie steeply inclined beds, we infer that the steeply inclined beds were folded before the overlying series was deposited, and that at a later period both series of rocks were together deformed. The relation between these beds is called an unconformity. In this district three unconformities are recognized, between the complex Grenville schist and the Poughquag quartzite, between the Ordovician shales and the Shawangunk conglomerate, and between the glacial drift and the formation upon which it lies.

Competency. In regard to the resulting structures, the character of the rocks affected is scarcely less influential than the mountain-building processes themselves. All rocks may be classed as competent or incompetent according to their behavior toward the forces tending to deform them. A competent layer is one able to sustain its own weight in a relatively large simple arch without crumpling. It will therefore yield to pressure by means of gentle, open folds. An incompetent bed, on the other hand, can not at all sustain its own weight and folds closely and compositely. Thus in the same folding very different effects are produced in different beds. A case rather commonly noted is that of an incompetent bed between two competent layers; the latter may fold in broad, gentle undulations while the inclosed incompetent bed will be much more complexly and steeply folded, often with evidences of drag along the margins, where the competent bed has moved as a unit over on

the incompetent layer. Such an effect may give the appearance of an unconformity. Of the formations with which we are dealing, the massive Grenville schists, the thick-bedded Poughquag quartzite, the Wappinger limestone, and the Shawangunk conglomerate are the competent members, and the Ordovician shales the incompetent. Both groups show folds and faults as the result of deformation. In the former these structures are on a relatively extensive scale, while in the shales, within these larger structures are many repetitions of the same features on a much more limited pattern.

Durability. Somewhat distantly connected with the relative competence of a rock is its durability, that is, its resistance to weathering which is determined mainly by the mineral composition, the structure, and the texture. The several formations outcropping in the Newburgh quadrangle withstand the weather differently. Upon the ancient crystalline schists and the massive firmly cemented conglomerates weathering makes slow headway. To a lesser degree this is true also of the fine-grained Cambro-Ordovician limestone and of the thicker sandstone beds in the shale series of Ordovician age. The great mass of the Ordovician shales, however, consisting of slaty beds and thin intercalated sandstones are closely folded and stand at steep angles. The agents of weathering, and especially water, find an easy entrance and cause rapid disintegration and decomposition along the closely spaced bedding planes. Weathering progresses very much more rapidly than with the other rocks in the area, which are either massive or thick-bedded.

Physiographic History

The territory included in the Newburgh quadrangle, lying almost entirely in the Great Valley, a broad lowland belt extending along the southeastern base of the folded Appalachian Province, shares in common with surrounding areas a history that is postulated in the following steps:

1 An ancient crystalline complex eroded to extreme old age
2 Submerged and covered with thick sediments
3 Subjected to repeated deformation resulting in much folding and faulting
4 Peneplained over a broad extent
5 Uplifted and peneplained only on the less resistant rocks, leaving the more resistant rocks to form ridges
6 Uplifted again and submaturely dissected
7 Glaciated
8 Dissected continuously since the retreat of the ice sheet

In the Newburgh district the evidences of this history are not entirely conclusive; without comparison with adjacent areas all the steps in the development could not be deciphered. Certain surface features, however, are recognized as having originated during one or another of the stages, and they will be briefly described in the appropriate place.

1 Only small remnants of the ancient crystalline complex are visible at the surface, the larger of these being Cronomer hill, the outstanding elevation in the southeast corner of the sheet. Along the eastern base of the hill, where a cover of younger rocks has protected it from erosion, the ancient peneplained surface (Precambrian) is exposed. Here it is evident that the old rocks were worn down to a gently rolling surface before later deposits buried it, thus removing it from the belt of superficial weathering.

2 Submergence of the ancient continent and burial under thick sediments are indicated by the presence of a thick series of marine formations, Poughquag, Wappinger, and Hudson River, which surround the remnants of the old continent that are exposed, and which earlier probably buried these as it now does the greater part of the ancient basement. Along the base of Cronomer hill and its extension to the south these rock layers may be seen lapping up on the flanks of the hill.

3 The area has been subjected to mountain-making disturbances: beds that were deposited in a horizontal position under water, are now tilted at all angles. A group of older sediments, Poughquag, Wappinger, Hudson River, appear to be more profoundly deformed than a later formation, Shawangunk. This fact is accepted as proof that movement occurred at two periods, one before, the other after, the deposition of the less disturbed member.

4 The old erosion surface generally known as the Cretaceous peneplain is not typically developed in the Newburgh quadrangle. Nowhere are there any indications of this surface except in the Shawangunk mountains where small areas, which reach an elevation between 1800 and 1900 feet, are thought to be remnants of it. Less doubt exists about the peneplain on the mountains a little farther west, on the adjoining Ellenville sheet, where several hills rise to about 2200 feet above sea level.

Below the Cretaceous peneplain several streams are now entrenched. The Palmaghatt, a branch of the Wallkill river heading on the mountain south of Lake Minnewaska, has cut a gorge through the

Plate 2

Peterskill Falls (Photograph by courtesy of E. A. Smiley)

hard conglomerate capping and into the softer slates below (immediately on the adjoining sheet). Its incision has cut off from the rest of the cliff a prominent point on the top of Millbrook mountain known as Gertrude's Nose. In its upper course the valley has a steep gradient and is wild and picturesque. The high, nearly vertical walls are smoothed and striated by glacial action and the valley floor is strewn with moss-covered blocks of the white conglomerate. The Palmaghatt is justly famed for its stately beauty and for the magnificent large hemlocks which constitute a "forest primeval" through which the sunshine penetrates only in small patches to the luxuriant growths on the wet valley floor. The other streams in the mountainous area have for the most part more open valleys. The Sanderskill, Peterskill and Coxingkill are flowing on the Shawangunk conglomerate parallel to the gentle folds in it and down their pitch to the north. The Coxingkill is the outlet of Lake Minnewaska and flows throughout its course in the quadrangle on the smoothed surface of the conglomerate. The Peterskill, flowing on the west flank of the anticline on which lies Lake Minnewaska, has cut through a great thickness of Shawangunk conglomerate, but neither it nor any of the other streams have cut through to the shales beneath. About three-quarters of a mile north of the lake, the Peterskill drops more than 60 feet over a vertical cliff of Shawangunk conglomerate, Awosting Falls, and a few hundred feet to the north, falls about 240 feet more in a series of beautiful cascades known as Peterskill falls (plate 2).

5 The most characteristic topographic feature of all parts of the quadrangle except the northwest corner, is the very persistent and gently rolling surface developed about 300 feet above sea level and now almost entirely hidden under glacial debris (plate 3). This is the erosion surface known as the Tertiary peneplain, which is cut more than 1500 feet below the remnants of the older peneplain (Cretaceous). Uplift interrupted the earlier cycle near its close, rejuvenating the streams, which in time cut a broad, low plane over the soft rock belt, truncating cleanly the upturned rock layers. The more resistant rocks were not reduced to the new level, but stand out as monadnocks, rising several hundred feet above the Tertiary surface. Cronomer hill, an inlier of Precambrian crystalline rock, and the Marlboro mountains, a high ridge whose backbone consists of massive Hudson River graywacke, represent unreduced areas or monadnocks on the lower peneplain.

There is little doubt that the present drainage in large part had its origin during the cutting of the Tertiary level. Most of the valleys are fairly open, even where they are entrenched below the

peneplain developed on the soft rocks. The master stream of the region, the Hudson river, just touches the sheet at the extreme southeast corner, and any discussion of its origin would involve a discussion of the physiographic history of extensive areas lying beyond the limits of the area under investigation. Since not all the points in its history are clear, it is not desirable to discuss it in connection with an area that throws no specal light on the problem. Most striking about the other drainage lines is their parallel arrangement, indicating that they are subsequent streams which have etched out their valleys along belts of weak rock during the reduction of the region to the Tertiary peneplain. If the Atlantic coastal plain lapped over the area, then the present drainage lines must have been initiated during the Tertiary dissection, and there is no question as to their ancestors on the so-called Cretaceous peneplain. If, however, this region was exposed during the development of that erosion surface, it is possible that the ancestors of the Wallkill and Shawangunk rivers may have occupied subsequent positions on the earlier (Cretaceous) peneplain.

6 The second cycle of erosion was interrupted by an uplift which initiated the third cycle, permitting the streams to intrench their valleys below the peneplain developed on the soft rocks.

7 The third cycle was temporarily interrupted by glaciation. The continental ice sheet overrode the area, scraping and polishing the tops of the hills and widening and deepening the preglacial valleys. On the crest of Cronomer hill the bed rock is smoothed and striated, and on the Marlboro and Shawangunk mountains every bare rock surface shows glacial scouring. The wind gaps used by roads that cross the Shawangunk mountains expose massive rocks that are so smoothed by the ice that they are dangerous for automobile travel.

The proofs of erosion by the ice are largely hidden by the deposits left by the same agent. Practically the entire district is covered by glacial drift, some of it modified by running water, and many of the hills consist entirely of drift. Some of the higher hills, for example King's hill, resemble drumlins in shape, but consist largely of rock with a cover of drift, thick near the base and thinner toward the top. A drift dam is thought to bound both Lake Minnewaska and Orange lake on the south. It seems probable that occasionally streams may have been displaced from their post-Tertiary valleys by glacial deposition, but, despite glaciation, the streams flow predominantly in subsequent valleys parallel to the strike of the structure. While marshes and lakes bear witness to the disturbing influence of the ice, glaciation has not profoundly affected the broader features of the drainage.

Plate 3

The drift-covered Tertiary peneplane. View taken looking northeast from the hill southeast of Montgomery.

8 Since the retreat of the ice sheet, erosion has produced little change in the surface configuration. Glacial drift still covers most of the surface. Some of the smaller streams are postglacial, and are very youthful, still flowing on the glacial debris. The larger streams, the Hudson and the Wallkill, have maintained their preglacial courses, although they flow for a large part of their length on glacial fill. The channel of the Hudson river at Newburgh is only 26 feet deep, the much deeper preglacial channel being choked with glacial debris. A cross section of the Wallkill valley (figure 3) shows the postglacial channel of the river in the thick glacial filling of its preglacial course.

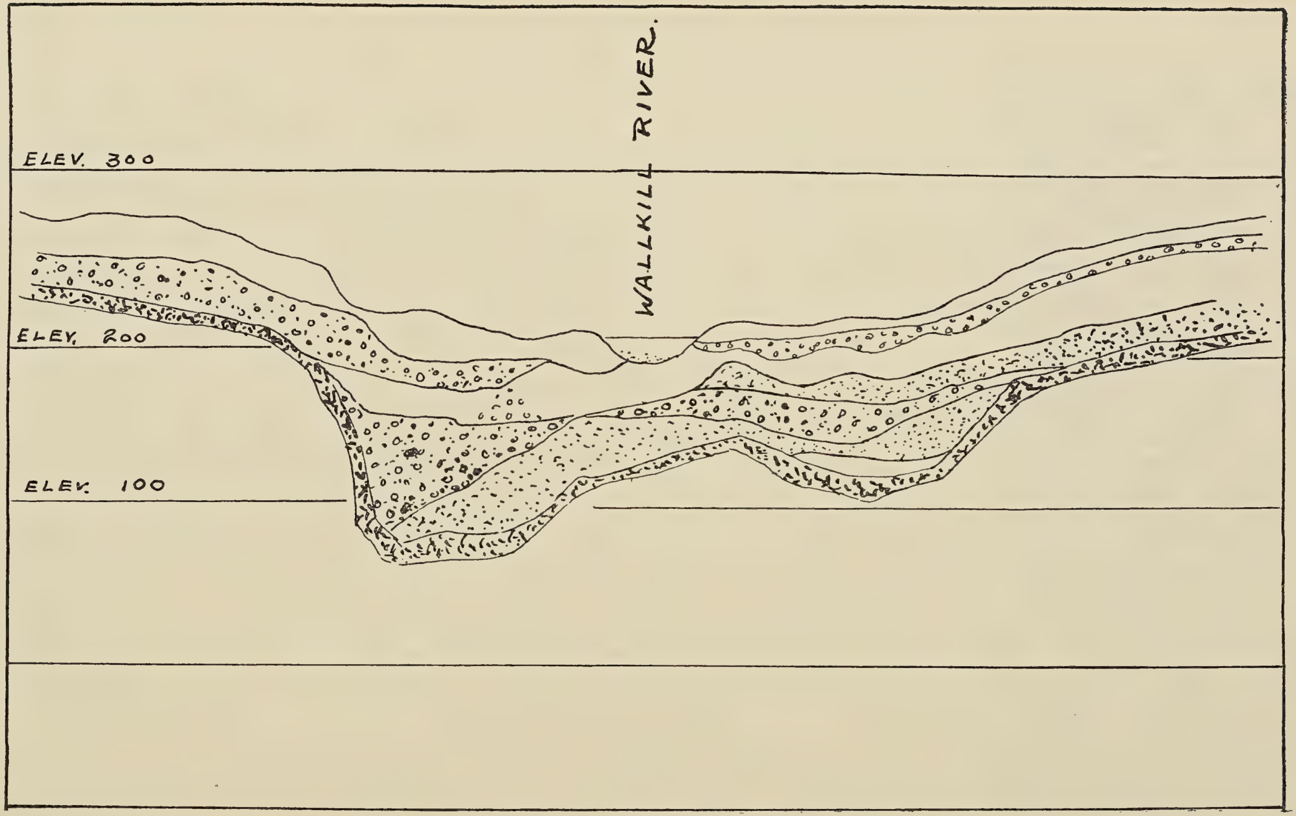


Figure 3. Wallkill Siphon

Profiles of the present and preglacial Wallkill channels near Libertyville, and a diagrammatic section showing the different types of drift-filling. Data from board of water supply, city of New York. Redrawn from plate 25 of the New York State Museum Bulletin 146.

The Wallkill river is one of the larger tributary subsequents to the Hudson river and the most important stream on the Newburgh sheet. Rising near Deckertown, N. J., it flows through the lowlands of Orange county and enters the Hudson at Roundout. For most of its course the Wallkill is a retrograde stream,[22] flowing in the opposite direction to the Hudson river, the master stream of the region. The current is nowhere rapid, except at Walden where there is a fall of 26 feet; it furnishes, however, extensive hydraulic power throughout its course. The river is generally muddy with a heavy load of sediment, and flows through a rather monotonous low country. One of the early inhabitants of Orange county has drawn this highly imaginative picture of the falls and its environs:

At Walden its banks are studded with evergreens, and its sides are walled in by the ever-enduring rocks, between which the waters lash and foam down a fall of 40 feet, throwing up a spray in which the sunbeam is gilded and garnished with all the hues of the rainbow. Here harnessed to wheels and gearing, the waters perform Titan labors for the prosperity of man.[23]

The most striking topographic feature in the whole region is the steep front face of the Shawangunk mountains (frontispiece). From the gently rolling floor of the valley, only 300 to 400 feet above sea level, the scarp rises on the average to 1200 feet within a mile or less, at the northern margin of the map in less than a half mile, and at Gertrude's Nose to 1800 feet in little over a mile. For practically its entire length the upper 200 feet of the cliff is almost perpendicular. The massive conglomerate forming it weathers very slowly; but large blocks, bounded by lines of bedding and jointing, and often weighing several tons, break from the face of the precipice, which thus recedes but remains as steep as before. Below the vertical wall comes a decided break in the slope, where very coarse talus entirely obscures the rock beneath. This dividing line is used by the exceptionally fine road, the Undercliff road, which is maintained by the Smileys, owners of the mountain, to connect the two picturesque points, Lakes Minnewaska and Mohonk. Although talus covers the surface below the break in slope, the latter is thought to define the contact between the massive cap rock and the soft shales, so that at least the lower 600 feet of the front face of Milbrook mountain is cut on these easily eroded rocks. Even at considerable distance the break in slope is noticeable because the trees and other

[22]Berkey, C. P. Geology of the New York City (Catskill) Aqueduct. N. Y. State Mus. Bul. 146. 1911. p. 68, 69.
[23]Denniston. N. Y. State Agric. Soc. 1862. p. 167.

vegetation that cover the talus are almost entirely absent from the cliff above. This feature is especially striking because of the contrast between the resistant conglomerate and the soft slates, which are easily removed, undermining the hard capping, and because of the joints in the conglomerate, which permit the receding of the cliff without the destruction of its nearly vertical face. At present the cliff is receding more slowly than formerly, due in part to the excellent protection the thick talus affords the weak foundation, and in part to the fact that the broad lowland to the southeast is not now being actively degraded, and no large stream is actively undermining the scarp.

TECHNICAL DISCUSSION

The Precambrian

The crystalline basement on which the Paleozoic strata rest is exposed in only two very limited areas in this quadrangle. The larger one constitutes Cronomer hill and the ridgelike stretch extending southward for 2 or 3 miles. This area is more than a mile wide at the north end and tapers to a point toward the south. It is undoubtedly bounded by a fault on the west side and also on the north, but its easterly limits are formed by the overlying Poughquag quartzite except at the south where a fault again cuts it.

A very narrow strip, in some places not 100 paces wide, lies a short distance east of this area, entering the quadrangle from the south as a continuation of the Snake hill ridge of the Schunemunk quadrangle, and dying out in a wedge to the north. This unit of crystalline rocks is very low and is covered so much by drift that it can not be followed as accurately as the larger area, and its relations are a little more obscure. Perhaps they could not be determined with entire satisfaction within the quadrangle itself. With this established as a continuation of Snake hill, however, it is certain that this strip also is bordered by faults, giving it a peculiar fault structure developed in connection with several of the Precambrian inliers. This is essentially a combination of faulting of two different periods, a combination of deformations which appears to have left this particular inlier at least as a wedge inlier without roots. (See discussion of fault structure for additional description.)

Character of the crystalline rocks. It would not be possible to establish satisfactorily a subdivision of the ancient crystallines from the occurrences in this quadrangle. It is clear, of course, that

there is a great variety of petrographic character and, to some degree, of types of crystalline rock, but how these are related to each other in detail could not be determined if it were not for the immediate proximity of this area to the large Highlands district where extensive studies have been made, and where much better opportunity for subdivision and determination of structural relations can be found. The discussion of the crystallines, therefore, is based essentially on comparison of these rocks with those considered fundamentally typical of the accepted formations of the crystalline rocks of the Highlands.

When this is done it is clear that at least three of the principal or standard types or formations are represented in the complex mixture found in the Newburgh quadrangle.

Since no argument is based on the material secured, it is evident that it will simplify the statement for the average student of the district to give an outline of the major features of the ancient crystalline geology as accepted in the West Point area,[24] the nearest recently studied portion of the Highlands.

Major features of the geology of the Highlands. 1 The first of the major features of the geology of the Highlands is an ancient series of sedimentary rocks of great variety and great thickness which had been thoroughly metamorphosed in very ancient Precambrian time. They appear to have been folded and to some degree affected by igneous intrusions before the more pronounced and simple types of igneous rocks prominently developed in certain portions of the Highlands were formed. This most ancient series is referred to as the Grenville series on the ground of its general similarity in structural relation and position to the Grenville of Canada. This series must originally have rested upon something still more ancient, but in no place thus far discovered in this or adjacent districts has any such basement been found.

2 The oldest well-developed or individualized unit next to the Grenville is chiefly igneous, or owes its character to igneous injection, and is dominantly medium basic in composition, in places essentially a diorite. This type or quality of rock has been described in numerous places in the Highlands and is a well-recognized formational unit where developed on a large scale. The name given to the type is Pochuck gneiss, from Pochuck mountain considerably southwest of the area under study, but along the same general strike of the formations. It is not always possible to distinguish this

[24] Berkey, C. P. & Rice, M. Geology of the West Point Quadrangle. N. Y. State Mus. Bul. 225–26. 1921.

type clearly from the more basic facies of certain of the granites, but it is a reasonably characteristic and constant petrographic unit. Although it is not represented in the Newburgh quadrangle in large enough development to warrant any attempt at field separation, it is represented in some of the specimens collected.

3 Next in age was a batholithic granite invasion which was apparently unusually successful in penetrating, in an intimate way, nearly all of the varieties of the older rock, the Grenville particularly, thus making exceedingly great modifications of their original habit and appearance, and making, on a large scale, mixed rocks quite unlike either of the fundamental types chiefly responsible for them. In some places the invading granite is comparatively free from Grenville contamination and in such places appears as a simple granite; much more commonly it preserves to some degree the streakiness and the banding and other peculiarities of the original Grenville. With equal frequency the granite appears in bands or streaks following the structural weakness of the original rock in *lit-par-lit* structure, giving rise to the banded gneisses that characterize some portions of the crystalline areas of southeastern New York. This type is not everywhere recognized in this same simple formation and is consequently confused in the formational naming of different districts. In the West Point area it is referred to as the Canada Hill granite type. It seems to correspond to the granite portion of the Losee gneiss of the New Jersey geologists.

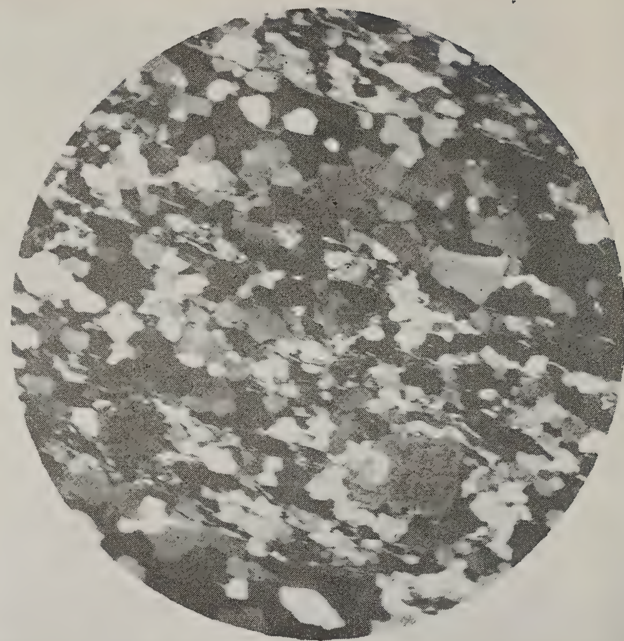
4 In the West Point quadrangle still other granites, apparently distinguishable from the Canada Hill type, are represented next in age, but they do not differ materially in their geologic occurrence or significance and may be essentially local representatives of the same general magmatic invasion. One of these of largest importance in the West Point quadrangle is known as the Reservoir granite.

5 The last one of these granite intrusions is the most massive of all and the least mixed or confused with the older rocks which it intrudes. It is a hornblende and hornblende-pyroxene granite in typical development, and has its simplest development in the ridge forming the northernly wall of the Highlands at Breakneck and Storm King mountains. It has, on this account, been referred to as the Storm King granite, but the same type occurs much more widely distributed; in the New Jersey areas it has been recognized as a petrographically distinct member, although it is not mapped separately from the included and older materials with which it is

Plate 4

Photomicrograph of a modified Grenville gneiss, from the little hill east of the northern part of Cronomer hill. No. 24–6. Taken with crossed nicols, magnification 25 diameters. The long mottled grains are anthophyllite, somewhat altered. Quartz occurs in the long clear light and dark areas between the anthophyllite grains and also in fine mosaic patches. The dark shapeless areas are much altered material, mainly limonitic. In other fields of this slide occur also alkali feldspar, biotite, graphite, pyrite and zircon.

Plate 5



Photomicrograph of a schistose quartzite belonging to the Precambrian area southwest of the city of Newburgh. No. 26–44. Taken in polarized light, with a magnification of 25 diameters. The large mottled grain is feldspar; the thin long flakes are sericite; all the other grains are quartz. The parallel arrangement of both sericite and quartz grains is evident, as is also the interlocking of the quartz grains.

associated. It seems to correspond, however, to the igneous member of the Byram gneiss of the New Jersey folios.

6 The only crystalline representatives later than the Storm King granite occur in the form of dikes or very small intrusions and are basic, again very similar in composition to the diorites of the Pochuck gneiss, yet are not to be confused with that formation, and are undoubtedly of very much later age geologically.

Local representatives. It is clear from examination of the material secured from the crystalline areas of this quadrangle that the following types are represented:

1 *The Grenville, in considerably modified form.* The bedrock of the little hill rising to 440 feet above sea level east of the northern part of Cronomer hill is a dense, mottled gray gneiss, weathering dark reddish brown. It is rich in quartz and in small flakes of graphite scattered through the rock. In thin section (plate 4) it is seen to contain also alkali feldspar, anthophyllite, biotite, garnet, pyrite and zircon. The rock probably represents an old Grenville sediment modified by an invading granite. Less changed is the schistose quartzite, occurring with the Precambrian rocks in the narrow wedge that enters the sheet south of Newburgh. In hand specimen it is a streaked light gray rock, slightly iron stained. Under the microscope (plate 5) the schistose character shows in the parallel arrangement of the elongate quartz grains and the sericite flakes. Microcline is present in very small quantity, as is zircon. This rock closely resembles the Lowerre formation of the Highlands and has doubtless had the same origin, the metamorphism, under dynamic conditions, of an old, probably Grenville, siliceous sediment.

2 *Traces of the oldest dioritic member, the Pochuck formation.* In the small wedge-shaped area of Precambrian rocks in the southeast corner of the quadrangle occur several varieties of the very ancient rocks. One of them is a massive, dark, mottled black and white rock, discolored by iron stain wherever it has been exposed to weathering. This is a peculiarly monotonous feldspar-hornblende rock, consisting of green hornblende and of oligoclase-andesine and andesine. It is similar to the Pochuck of New Jersey and of the West Point quadrangle, and is considered to be syntectic or mixed rock, the diorite magma having invaded and assimilated some of the ancient Grenville formation. The rock has been crushed, as appears only in thin section. The photomicrograph (plate 6) shows micro-faulting and bending of the albite twinning lines. In other fields in the same slide the effects of crushing are much more evident; large patches

consist entirely of a fine mosaic of hornblende and plagioclase, the result of mashing, perhaps in a fault zone.

3 *Granitized portions or syntectics apparently representing some portion of the early batholithic granite invasion, probably equivalent to the Canada Hill type.* In some places rather clear granite and pegmatitic phases of granite may represent the same member. The road that extends northwest-southeast at the northern base of Cronomer hill has exposed the old crystalline rocks for some distance. Much of it is a graphitic schist, but among other types there is a medium-grained white granite, with patches a half-inch in diameter of light pink garnet, quartz and graphite. The groundmass is light in color and contains quartz, sericitized plagioclase, bleached biotite, garnet, and also in smaller amounts apatite, destroyed pyroxene, zircon and rutile (plate 7).

4 *Material of Storm King granite type.* A medium-grained black and white mottled granite occurs at the southern base of Cronomer hill, just north of Quassaic creek. In hand specimen it is markedly gneissoid, due to the arrangement of the hornblende in streaks. Under the microscope it is closely similar to the Storm King granite of the West Point quadrangle, having an abundance of microperthite and very pleochroic hornblende and biotite. The essential minerals are quartz, perthite, oligoclase, brown hornblende, biotite and pyroxene. Also present are the accessory minerals zircon, apatite, hypersthene and pyrite.. The rock is fresh except for a slight kaolinization and sericitization of the feldspars. Some fields under the microscope are not typical Storm King granite, but seem to indicate a later acid *lit-par-lit* injection, while others contain small nearly digested fragments of earlier igneous rocks, possibly of the Canada Hill or Reservoir granites.

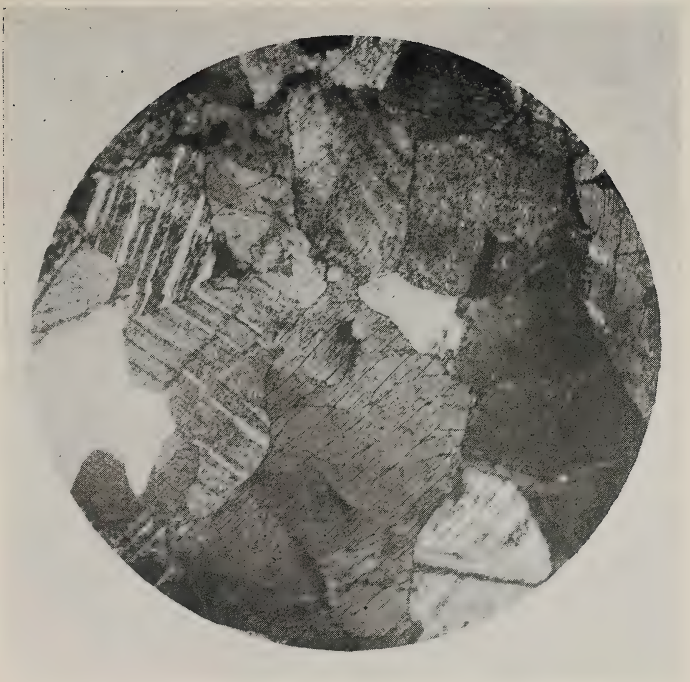
Paleozoic

Poughquag[25]

As is commonly the case in eastern North America, the first of the sediments overlying the Precambrian basement is a relatively pure quartz rock. The quartzite and conglomerate occupying this stratigraphic position in the region north of the Highlands of the Hudson is known as the Poughquag. In the district under study it outcrops only in one long narrow zone bounding the eastern side of the Precambrian mass of Cronomer hill.

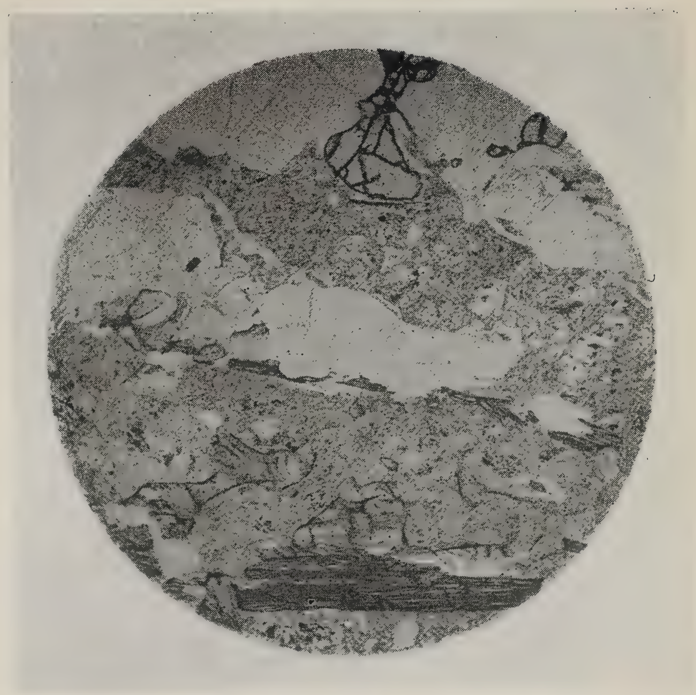
[25]Dana, J. D. Amer. Jour. Sci., ser. 3, 3:250–56. 1872.

Plate 6



Photomicrograph of the Pochuck Grenville rock, a mixed type, in which the Grenville has been invaded by the Pochuck diorite. No. 30–45. Taken in polarized light; magnification of 25 diameters. Plagioclase, of the composition of oligoclase-andesine and andesine, shows up as the striped grains (albite twinning) which exhibit microfaulting and bending, and also as the rough altered looking areas. The abundant dark rough grains with distinct cleavage are hornblende.

Plate 7



Photomicrograph of a granitized portion of the Grenville, a syntectic. No. 29–46. Taken in plain light; magnification 30 diameters. Clear light grains are quartz; the rough light gray grains with the strong outlines are garnet. Biotite shows up as a dark shredlike mineral; it has been bleached. The large dull pepper and salt areas represent plagioclase that has been altered to an aggregate of carbonate and sericite. Pyroxene (destroyed) also appears in the slide.

The Poughquag is a well-cemented, exceedingly resistant conglomeratic quartzite. The color is varied; white, (slightly yellow with iron stain), blue gray, and mottled deep pink, yellow and white, are the commoner types. It is uniformly feldspathic and free from ferromagnesian content, although a few small grains of a black mineral (probably tourmaline) are scattered throughout. The poor sorting of the material is evident in an examination with a hand lens. Even in the uppermost bed which is visible in the area and which is finer textured than the beds below, the grains vary up to one-quarter of an inch in diameter. The rock is heavy and dense, and exceedingly hard. The portions exposed within the quadrangle are unusually coarse, the formation elsewhere being known as a strongly bedded silicified sandstone of medium grain, grading into a fine conglomerate at the base. In all of the outcrops in the Newburgh region it is uniformly coarse, many of the pebbles reaching one-quarter of an inch in diameter. On account of the relatively large size of the grains, a first glance discloses the poor sorting of the fragments.

In thin section this character is very evident (plate 8). In the field shown in the photomicrograph quartz occurs as the most abundant mineral, and varies in size from granules less than .04 mm to .1 mm in diameter. Other fields in the same slide exhibit much larger grains of quartz, and a hand specimen shows pebbles of the same mineral a quarter of an inch in diameter. Some of the quartz grains are composite; some were fractured and healed with vein quartz before incorporation in the Poughquag; others show strain effects. Slightly kaolinized feldspars, orthoclase and microcline, occur in small quantity, and in interstitial positions, large grains of tourmaline, and apatite and zircon, which also appears in small crystals. Iron oxides outline the grains and with carbonate, leucoxene and sericite, make up the binder for this conglomeratic quartzite. The quartz grains have slightly interlocking margins, due to reorganization of the silica, so that the angular or subangular shape of the fragments is changed. In hand specimen the rock is a light gray quartzite, with a few small pebbles scattered infrequently through it. Exposed surfaces are stained yellow by the iron oxide.

The second photomicrograph (plate 9) shows a somewhat coarser type of Poughquag, a commoner type in this area. In it most of the field is occupied by a single composite grain of quartz which exhibits the interlocking habit and crushed character and strain effects inherited from an old crystalline rock. The section shows also small grains of microcline and orthoclase, slightly altered, and simple quartz grains, with margins interlocking from reorganization within

the rock itself. In the interstices between the larger grains occur tourmaline, sometimes in large pieces, and zircon. The larger grains are outlined with iron oxides, and in the cementing material are also sericite and leucoxene. In hand specimen the rock is a dark gray, fine-grained quartz conglomerate, stained dark rust color wherever exposed. The dark color may possibly be due to the presence of some smoky quartz among the more generally clear grains.

The Poughquag covers a small area along the southeastern base of Cronomer hill. The outcrop is seen for about 100 feet along the road which cuts through it and exposes a low cliff from 5 to 7 feet high. The rock weathers dark and red, and might easily be mistaken, in hurried examination, for the crystallines which constitute the contiguous Cronomer hill and extend to the northeast as the bedrock for a considerable distance over the lower country. The beds dip very gently, 12° to the east; and strike north 40° east. The surface westward as far as Gidneytown creek, just before it swerves to the east, is floored by the quartzite, and is wooded and only moderately covered by rock debris. Immediately west of the creek at this point the bedrock is Grenville. The creek seems to be flowing along the contact of these two formations, and the contact is therefore not visible. The relation, however, is quite apparent—an unconformable sedimentary contact, the Poughquad laid down by a sea advancing upon an old land long exposed to erosion. The unconformity is an angular one, the crystallines dipping steeply east, whereas the dip of the quartzite is gentle in the same direction.

To the south for at least a quarter of a mile along the west side of Quassaic creek, about a half-mile north of Glenwood Park, the southward continuation of the Poughquag belt is visible. Here the massive beds dip 30° to the east, and the slope down to the creek is

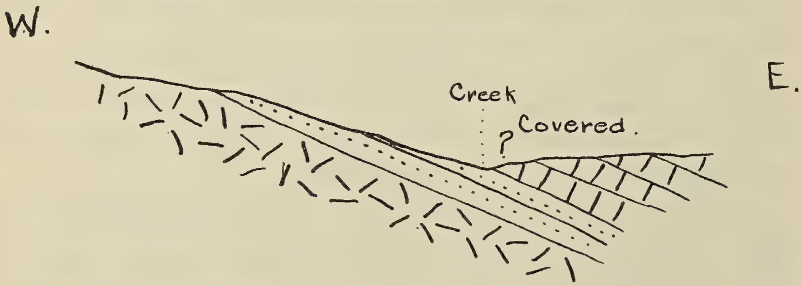
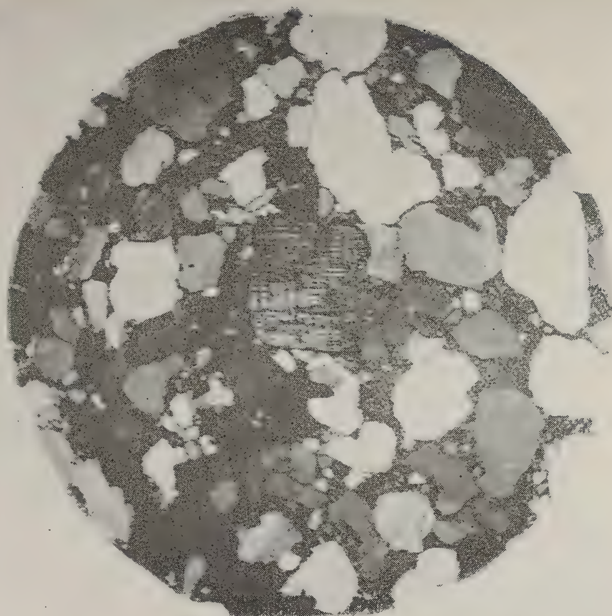


Figure 4

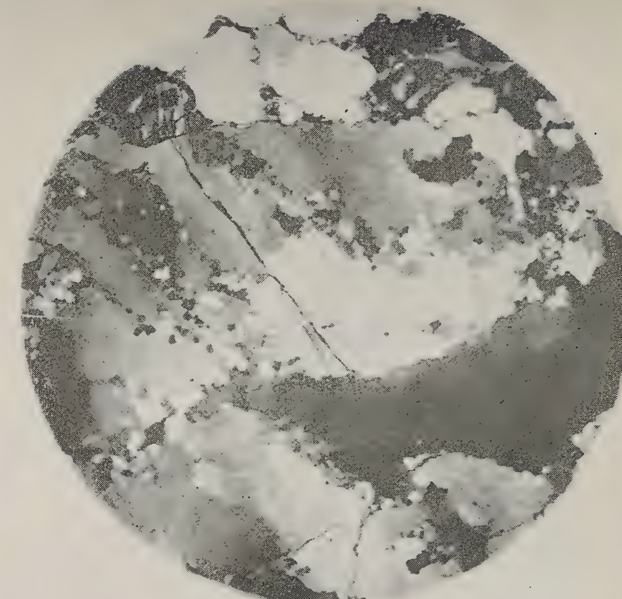
very nearly the same. Much of the surface is covered by large rectangular blocks of the quartzite. The near-dip slope down to the creek

Plate 8



Photomicrograph of the Poughquag quartzite from the southern part of the belt of Poughquag in the Newburgh quadrangle, south of Quassaic creek. No. 12–50. Taken with crossed nicols, magnification 25 diameters. Quartz is by far the most abundant mineral, and by its interlocking habit makes the rock very strong. The streaks in many of the quartz grains are lines of inclusions, showing the mineral to be of igneous origin. In the center of the field appears one large fragment of microcline. Among the smaller grains other than quartz occur tourmaline, microcline, zircon and apatite. Interstitial material is not in large amount and consists of carbonate, silica,

Plate 9



Photomicrograph of conglomeratic Poughquag quartzite from the belt of Poughquag just north of Quassaic creek. No. 14–51. Taken with crossed nicols, magnification 25 diameters. This photomicrograph shows a coarser phase of the Poughquag. The compound grain of quartz, which occupies almost the entire field, is part of a pebble of quartz derived from an older igneous or metamorphic rock in which the interlocking character of the grains, as well as the granulation and strain shadows are seen. Also visible above this composite fragment are simple quartz grains and one of microcline.

is strikingly smooth, and seems to be due to glacial action, which accounts in part, no doubt, for the great angular masses of the quartzite lying helter-skelter on similar rock in place, and more certainly for the drift cover.

These outcrops are the only conspicuous ones of the quartzite belt which extends about 2 miles from northeast to southwest and limits the crystallines on the east. At the northern end the Poughquag ends suddenly against a fault which cuts across obliquely, bringing Hudson river beds against Wappinger, Poughquag and Grenville. At the south the quartzite is again cut out by faulting, disappearing gradually with the wedging out of the crystalline block to which it belongs (see structural cross sections). The thickness of the quartzite is estimated to be about 125 feet.

In Dutchess county the Poughquag quartzite outcrops over much larger areas than on the west side of the Hudson river, and there several localities yielded recognizable fossils. Olenellus, probably O. thompsoni, spines of trilobites, brachiopods, resembling Obolella, and Scolithus linearis are listed by Gordon.[26] The Lower Cambrian age is thus established. Although no fossils were found in the Poughquag in the Newburgh area, its horizon is accepted as Lower Cambrian too, since it occupies the same stratigraphic position as the quartzite across the river. In lithologic characters also the two are similar, the chief difference being the greater coarseness of the formation as seen in the outcrops in Orange county. This very coarseness may account for the absence of fossils, which would be destroyed easily by contact with the larger and heavier fragments.

The most interesting problem connected with the Poughquag is that of its origin. What is the source of the relatively pure quartz grains? Wherever we look at the basal member in northeastern North America, we are struck by the significant facts that the rock is always a dominantly quartz rock, that it lies on the smooth surface of older rocks, and that it is followed, generally conformably, by a limestone. Above the Precambrian basement in Massachusetts and New Hampshire lie the Vermont quartzite and Stockbridge limestone; in Virginia and Pennsylvania, the Chickies quartzite and Shenandoah limestone; in the Arbuckle mountains the Reagan sandstone and Middle Cambrian limestone; in New Jersey the Hardyston or Reading quartzite and the Kittatinny limestone; in

[26]Gordon, C. E. Geology of the Poughkeepsie Quadrangle. N. Y. State Mus. Bul. 148. 1911. p. 45, 46.

New York State it is either the Poughquag quartzite or Potsdam sandstone and a limestone. In each case an ample source of supply is to be found in the long-continued weathering of the crystalline floor upon which the sea advanced. In the breaking down, however, of a crystalline mass, of which quartz certainly does not make up 50 per cent, what has happened to the other 50 per cent which weathered no doubt to fragments of very small size? In a normal series of deposits, it should constitute the stratum overlying the basal beds; in other words, a shale ought to overlie the sandstone, yet, as demonstrated above, limestone commonly follows immediately upon the basal sandstone in eastern North America. How can these facts be accounted for? Grabau[27] says that North America, at the beginning of Paleozoic time, was a broad peneplain, its surface interrupted here and there by monadnocks, and covered with almost pure quartz sands. The finer rock waste was carried away by the wind and the surface of the sand-cover swept clean before the advance of the sea and the deposition of the limestone. In this way he explains the absence of the fine material which should have been deposited as mud upon the sand. The efficacy of the wind in carrying off the dust of weathering seems all the more explicable because of the universally accepted theory that at the beginning of the Paleozoic there was no vegetation to anchor the sands, which were, in consequence, subjected to continuous shifting and sorting by the winds.

Somewhat later in the geologic time scale there occurs a similar succession which is perhaps more satisfactorily explained. In the Mississippi valley the St Peter sandstone is followed by a limestone. The hypothesis advanced to account for the absence of the shale member here is the development of the St Peter by the erosion of an older sandstone which was itself a pure quartz rock. This older sandstone, postulated as source of the St Peter, is in fact the basal sandstone, whose origin we are trying to solve. Is it possible to shift the onus one step further, and propose the derivation of the Poughquag from a still older quartz sediment? For such a theory there is, to be sure, some basis. Among the old complex of rocks known as the gneisses of the Highlands, Berkey[28] has identified a quartz schist, commonly known as the Lowerre quartzite. In the Precambrian rocks outcropping in the Newburgh quadrangle remnants of a similar quartz schist have been identified. This schist is of such a

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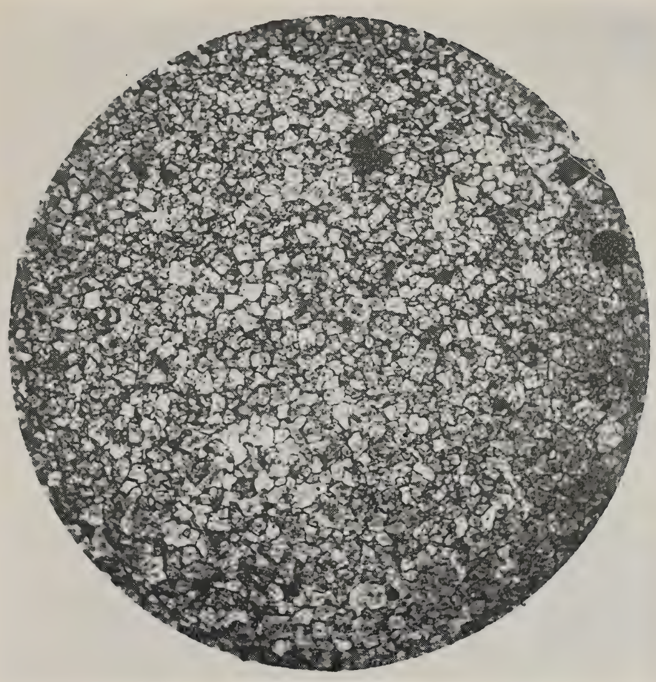
[27] Grabau, A. W. Lecture notes.

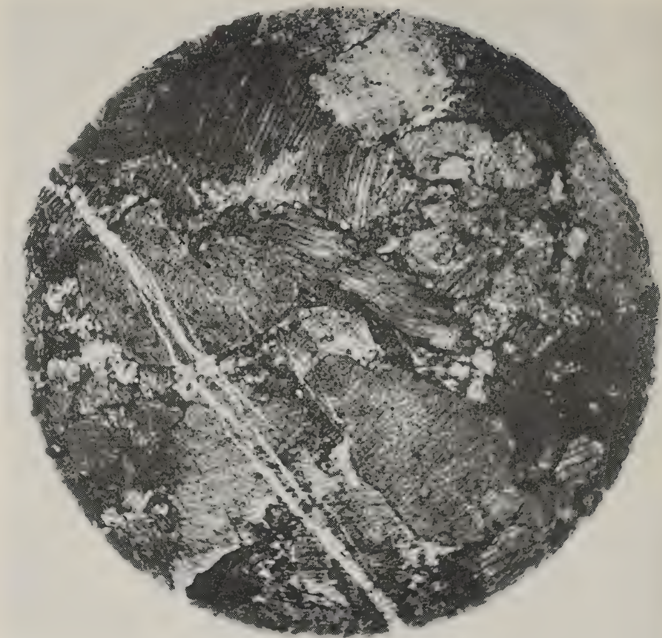
[28] Berkey, C. P. Structural and Stratigraphic Features of the Basal Gneisses of the Highlands. N. Y. State Mus. Bul. 107. 1907.

Plate 10



Photomicrograph of the Wappinger limestone from outcrops along the road a mile south of Glenwood Park. No. 3–7. Taken in plain light, magnification 25 diameters. This photomicrograph shows typical evenly fine-grained Wappinger limestone, in which all the granules, with the exception of a few tiny sand grains, are carbonate. The material is very little reorganized.

Plate 11



Photomicrograph of the so-called Trenton limestone from near the eastern border of the quadrangle north of Balmville. No. 2–32. Taken in plain light, magnification 25 diameters. The coarse fragmental character of the rock is evident. In this field are fragments of older limestones, of a fossil (indicated in the round control of one of the carbonate fragments), and large dolomite grains. The veinlets of calcite that cut across the photo show the shattering the rock has undergone.

character (see discussion of the Precambrian, pages 26-30) that it is not considered probable that the parts of it now missing through erosion could have furnished the material for the basal rock; but other sandstone beds, which overlay the Lowerre and which have been entirely destroyed so that no trace of them has been discovered, may have been the source of the pure rounded quartz grains. In the Precambrian sediments of the Adirondacks Kemp[29] has noted quartzites and quartzose gneisses, and so has Alling[30] and others. The Precambrian sand rock may be thought of as a member of a normal series, sandstone, shale and limestone, and thus obviate the difficulty of explaining the absence of any traces of the fine rock debris from the weathered crystallines.

Wappinger Terrane

The early Paleozoic limestone of southeastern New York has long been known as the Wappinger limestone from its occurrence along Wappinger creek in Dutchess county, where it is developed in several broad belts[31]. Of these the westermost extends into Orange county, crossing the river just south of Marlboro and covering a considerable area in the southeastern corner of the Newburgh quadrangle.

The rock is a compact, massively bedded dolomitic limestone of at least three types, a light gray, fine-grained variety (plate 10), the prevailing type, a darker bluish gray, coarsely crystalline variety, and a crystalline conglomerate (plate 11). In practically all the outcrops the limestone is conspicuous for its brecciated appearance, an intricate pattern of cracks in several intersecting series standing out distinctly and emphasizing the fractured character of the rock. Although all the cracks are cemented by carbonate, the resistance of the thin cementing veins varies; in some places jagged plates, doubtless containing magnesium carbonate, extend knifelike out from the rock; in others, long narrow furrows, due to erosion of the vein material, in this case probably the more easily soluble calcium carbonate, crisscross the limestone in all directions (plate 12). In many outcrops the healed fractures are so complicated and persistent and the limestone so massive that the dip is very difficult to determine.

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[29]Kemp, J. F. Precambrian Sediments in the Adirondacks. Proc. Amer. Ass'n Adv. Sci., 59:8–10. 1900.

Precambrian Formations in the State of New York. Extract du Compte Rendu du XI. Congrès Géologique International. 1910. p. 707–9.

[30]Alling, H. L. Problems of Adirondack Geology. Amer. Jour. Sci., 4th ser., 58:51–53. 1919.

[31]Dwight, W. B. Amer. Jour. Sci., 3d ser., 17:389-92. 1879.

In field work in this and neighboring regions the light gray, fine-textured limestone, which is tough and breaks with a conchoidal fracture, has been generally considered Beekmantown in age, in contrast to the dark bluish gray, coarsely crystalline limestone which has been called Trenton. The latter type is relatively rare, so that the term Wappinger, applied to the Cambro-Ordovician limestone of southeastern New York, designates the common light-colored, finer-textured variety.

The Wappinger limestone is thought to be the middle member of a comformable series, lying upon the Poughquag and below the Hudson River slates, but itself consisting of several members separated by gaps in deposition. At no place within the quadrangle, however, is there an outcrop favorable for determining the stratigraphic position of the limestone, the contact between it and the overlying and underlying formations never being visible, although in several localities a few feet of covered ground, as for instance, a road, separate them.

The Eastern belt. The eastern belt of Wappinger on the Newburgh sheet, approximately a half-mile in width, forms the bedrock of the higher land a short distance back from the river north of Balmville. To both east and west the limestone is bounded by the slates of the Hudson valley, and on both sides the dividing line between the two formations is hidden by roads. The eastern of these is known as the River road, from which a little north of the quadrangle limits, a beautiful view up the Hudson river is to be had. North from Balmville the belt of limestone extends along the western side of this road, where near the eastern margin of the sheet, it stands out as a nearly vertical cliff 20 to 30 feet high, the most satisfactory outcrop of the Wappinger in the whole region; for here the only fossils of value in correlation were found. This fossil locality has been known since 1880, when W. B. Dwight[32] identified from it the following forms[32a]:

Abundant small encrinal columns
Abundant fine Chaetetes (probably Solenopora)
Abundant Orthis (Dinorthis) pectinella
Abundant columns of Schizocrinus nodosus
Abundant Strophomena (Rafinesquina) alternata
Abundant Chaetetes (Solenopora) compacta
Abundant Chaetetes lycoperdon var. ramosus

[32] Dwight, W. B. Amer. Jour. Sci., ser. 3. 19:35. 1880.
[32a] The names in parentheses are those by which the forms are now known.

Plate 12

The typical weathered surface of the Wappinger limestone in an exposure on the limestone ridge southwest of Leights pond.

Several Rhynconella (Rhyncotrema) capax
Several Leptaena (Plectambonites) sericeus
Several Orthis (Platystrophia) lynx
Headplates of Echinoencrinites (Cheirocrinus) anatiformis
Discina n. s. conica
Probably Petraia corniculum
Indistinct Brachiopoda

Careful consideration of the foregoing list shows the Trenton aspect of the fauna; but very few of the forms as here identified can be used in closer correlation, either because the species has a long range or because the propriety of its identification is questioned. Further exploration in this outcrop resulted in the discovery of Strophomena (Rafinesquina) deltoidea and a new species of Triplecia[33] and also in the identification of some of the crinoid stems as Cleiocrinus magnificus and C. grandis.[34]

In the investigations undertaken for this paper many fragments of small and large crinoid stems and plates were found, also great numbers of fragments of Dalmanella testudinaria, Plectambonites sericeus, and of several other brachiopods which could not be determined; also Solenopora, identified provisionally with S. compacta Billings, although it was found to differ from the latter in having much smaller tubes, the tubes having a diameter ranging from .03 to .05 mm (plates 13 and 14). In size of tube this form agrees with Solenopora spongiodes Dybowski[35] and with S. gotlandica Rothpletz,[36] but differs from the former in the absence of the fine wavy course of the cell walls in longitudinal section. No effort will be made at this time to decide upon the affinities of the Newburgh Solenopora, because so far it has not been found in sufficient numbers to determine whether the size of the tubes is an individual peculiarity (due to age, perhaps) or a specific one. Besides, the original description of Solenopora compacta Billings is extremely vague; the holotype needs to be examined and redefined before further subdivision can be attempted. It seems probable, however, judging from the published descriptions and illustrations which are generally poor, that in most of the locali-

[33] Dwight, W. B. Trans. Vassar Bros. Inst., v. 1. 1881–83. p. 141–52.
[34] Ford, S. W. & Dwight, W. B. Amer. Jour. Sci. 31:251. 1886.
[35] Dybowski, Die Chaetitiden der Ostbaltischen Silur. Formation, St. Petersburg, 1877, p. 124, pl. 2, figs. 11*a-b*.
[36] Rothpletz, Aug. Uber Algen und Hydrozoen in Silur. von Gotland und Oesel, Kungl. Sv. Vet. Akademiens Handlingar, Band 3, no. 5. 1908. p. 14.

ties where Solenopora compacta is found, forms with both relatively small and large tubes are present. The general conception is nevertheless, that S. compacta has tubes of relatively large diameter, larger than those in the Newburgh specimen. Several species of Bryozoa, which have proved more satisfactory for correlation, were also found by the writer. They are:

Phyllodictya varia Ulrich
Batostoma winchelli Ulrich
Helopora divaricata Ulrich
Rhinidictya mutabilis Ulrich
Phaenopora incipiens Ulrich
Arthropora armatum Ulrich
Nematopora granosa Ulrich
Eridotrypa aedilis minor Ulrich[37]

Being of very limited vertical range, these Bryozoa are excellent index fossils. The first two are described from the "Trenton" shales at Minneapolis, Minn., and other localities, where they occur in the middle third of the shales, Decorah in age[38] which represent the probable time equivalent of the Amsterdam limestone of the Mohawk valley. In the lower third of the same shales is found Helopora divaricata,[39] and Rhinidictya mutabilis occurs in the middle and lower portions. The remaining four appear in the Prosser limestone of Minnesota,[40] a horizon correlated with the Glens Falls limestone. Rafinesquina alternata, similar to that in the Galena shale, Minnesota, is also found. It is probable that there are several genera and species present in this limestone conglomerate that have not been identified on account of the deeply weathered condition of the surface on which the fossils are visible, and on account of the fragmental character of the fossils themselves.

The limestone in which the above-listed forms occur is a dark bluish gray, crystalline limestone in fresh exposure. Its true makeup is evident only after weathering has taken place, when it is seen to be conglomeratic (plate 15). On the weathered surface pebbles up to 2 and 3 inches long stand out in relief, and much of the area not included in the pebbles is entirely covered by fragments

[37]Bryozoa determinations by Professor J. J. Galloway of Columbia University.

[38]Ulrich, E. O. Geology of Minnesota, Paleontology, v. III, pt 1. 1893. p. 145–295.
Bassler, R. S. Early Paleozoic Bryozoa of the Baltic Provinces, Bul. U. S. Nat. Mus. 77. 1911. p. 29.

[39]Ulrich, E. O. *Loc. cit.* p. 192.

[40]Ulrich, E. O. *Loc. cit.* p. 96-333.

Plate 13

Plate 14

Photomicrographs of Solenopora compacta Billings. Magnification 30 diameters. From the Balmville conglomerate north of Balmville. Transverse and longitudinal sections, showing the small size of the tubes.

Plate 15

Weathered fragment of the typical Balmville conglomerate from the limestone ridge north of Balmville. Natural size.

Plate 16

Weathered piece of the Balmville conglomerate from the limestone ridge north of Balmville. Fragments of crinoid stems make up much of the rock. Natural size.

of fossils. Although the latter are so numerous that parts of this facies of the limestone appear to consist almost solely of fragments of fossils (plate 16), the more complete forms lying in a matrix made by the comminution of similar bodies, the rock would hardly be recognized as containing fossils at all if weathered surfaces were not visible. The pebbles are chiefly of a light gray, fine-grained limestone, which resembles closely the typical Wappinger limestone of the district. There are also pebbles of a coarse-textured limestone and of black chert. These were fractured and healed before incorporation with the fossil fragments in the coarsely crystalline cement. The original material of the limestone has been slightly reorganized only so that the shell structure and composition is generally preserved. Within very short distances the rock changes from a coarsely crystalline limestone made up almost entirely of the fragments of crinoid stems, brachiopods and bryozoa, with a few pebbles scattered through, to a conglomerate which is so crowded with pebbles, that there is only a small amount of either cementing material or of fossils. Some of the pebbles are worn colonies of Solenopora compacta. This rock has suffered the same shattering as has the typical Wappinger limestone of the region, and shares with the latter the peculiarly fretted appearance, which has resulted from the weathering of the healed fractures.

This exposure of the conglomeratic limestone is the only one observed within the Newburgh quadrangle. Much more numerous are the occurrences of it just across the river in Dutchess county, where Gordon[41] found the conglomerate with massive limestone beds above and below. These he considered to be distinct both in fauna and lithology and to be separated by the conglomerate which marks the break between the Beekmantown below and the Trenton above.[42] Not only is this outcrop of conglomeratic limetone unique in the Newburgh area, but it is also the only outcrop of the limestone of whatever phase, that, in the region under study, carries any determinable traces of life. From a careful study of the fossils in the conglomerate north of Balmville, the break indicated by it is concluded to mark a time immediately preceding the Trenton, late Black River, or the earliest stage of the Trenton itself.

This conglomeratic and fossiliferous phase of the limestone is very thin as it is seen in its unique outcrop north of Balmville, probably not over 20 feet thick. Lying above it and below the Hudson

[41]Gordon, C. E. *Loc. cit.* p. 52–54, 62–64, 75, 89–92.
[42]Gordon, C. E. *Loc. cit.* p. 64.

River slates, however, are about 50 feet of limestone, which underlies the road and lower country just east of the cliff, and is largely covered. Where it has been examined in much fractured outcrops east of the river road, it appears to be very similar in lithogic character to the typical Wappinger limestone of the area, although it is decidedly younger than the last-named. Thus the early Trenton limestone must be something over 50 feet thick. This limestone which has heretofore been known as the Trenton, the writer proposes to name the Balmville limestone, from its very fossiliferous outcrop north of Balmville.

The origin of the conglomerate bed is not at all evident. That the pebbles in it were not transported great distances is indicated by the large fragments of fractured limestones which could not have endured a long attack, and by the presence in close proximity of the rock from which the pebbles seem to have been derived. Conditions must have been such that wave erosion, most effective in times of storm, could cut into more than the surface layer of rock. In the case of a small fold extending nearly parallel with the shoreline, or of several beds being exposed near the shoreline, waves might be cutting into the earlier rocks, so that fragments of these were deposited along with fragments of the hard parts of the animals then inhabiting the waters.

Only the front face of the ridge west of the river road consists of the conglomeratic and fossiliferous limestone. Climbing up, one crosses bed after bed of the usual brecciated, fine-grained limetone, standing with steep dip to the east. Some of the beds are very cherty, and a few seem to consist entirely of black chert. On this ridge are located many beautiful homes, the entrances and grounds of which are ornamented with large pieces of the limestone, after weathering has enhanced its appearance by bringing into relief the cemented fragments. These are known as "rustic rocks." Such thick drift covers the surface to the west that the exact extent of the limestone is not known. To the south this belt is thought to end abruptly, cut off by a diagonal fault, along which the southern continuation of the belt moved slightly to the west.

A formation of similar character has been described by Ruedemann[43] as the Rysedorph Hill conglomerate. Although this limestone conglomerate contains a very rich and varied fauna, the exact age it represents is still in doubt.[44] At several other localities north

[43]Ruedemann, Rudolf. Trenton Conglomerate of Rysedorph Hill, Rensselaer County, and Its Fauna. N. Y. State Mus. Bul. 49. 1901.

[44]Ruedemann, Rudolf. Paleontologic Contributions from the N. Y. State Museum. N. Y. State Mus. Bul. 227-28. 1919. p. 129.

of the Newburgh area limestone conglomerates have been noted and have been correlated with that of Rysedorph Hill. One of these, about 12 miles east of Saratoga Springs, is associated with the Bald Mountain limestone.[45] Another is the Burden conglomerate of Becraft mountain.[46] In each of these occurrences either faulted or masked contacts conceal the stratigraphic relations.

The structural relations of the limestone north of Balmville are similarly unfavorable. The beds dip steeply to the east, about 60°, as is seen by following the bed of conglomerate up the face of the cliff, and strike north 35° east. Hudson River slates border the belt on the east and west, but neither contact is visible. The slates on the east, dipping steeply east, are apparently conformable with the limestone. The gravity fault, however, that bounds the southwestern unit of limestone on the east is postulated as continuing along this belt also. The slates on the west have been overridden by the limestone in a thrust fault. As well as can be judged from this one outcrop, the uppermost beds of the limestone, and these include the conglomerate, are overlain by slates Snake Hill in age. Its relation to the Normanskill is not known, because the Normanskill has not been recognized in the region. If the writer is correct in considering these slates of Snake Hill age, then the Normanskill must either be entirely absent as such and its time equivalent be a part of the limestone or of the Snake Hill slate, or it is interbedded with the limestone.

The Western Belt. The mass of the so-called Wappinger formation near Newburgh (also known as the Neelytown, Newburgh, or Barnegat limestone) is the bedrock of a belt 2 miles wide on the average, extending from northeast to southwest west of Newburgh, and is the rock that was formerly burned for lime. In it fossils are extremely rare; in fact, in field work of two summers in the area, no identifiable form was found. On the Newburgh-Montgomery turnpike a mile west of Newburgh a cut exposed Cryptozoon-like markings. In the large outcrop the Cryptozoon character is apparent (plate 17) but in small pieces the similarity disappears almost completely, and thin sections disclose no organic structure whatever.. A siliceous bed in the same outcrop is very much weathered, and the innumerable small hollows and furrows look as if they are the molds of small brachiopods, but not one form can be

[45]Cushing, H. P. & Ruedemann, R. Geology of Saratoga Springs and Vicinity. N. Y. State Mus. Bul. 169. 1914. p. 75–80.
[46]Grabau, A. W. Stratigraphy of Becraft Mountain, Columbia County, N. Y. Report of the N. Y. State Paleontologist. 1902. p. 1035.

identified. There is much chert in some of the beds. The limestone at this spot has the appearance of the Hoyt limestone of the Upper Cambrian. Since that horizon is probably present in the lower part of the Wappinger formation in the Newburgh area, as it is in the Poughkeepsie quadrangle directly east,[47] this outcrop is correlated with the Hoyt. Ries considered all the limestone west of Newburgh Cambrian.[48]

The specimens of "Maclurea magna" that Whitfield discovered in the limestone at the northwest base of Snake hill,[49] in the continuation of this belt southwest of Newburgh, have been recently identified as Eccyliopterus planidorsalis or E. planibasalis Ulrich, Ms. These gastropods have been found by Ruedemann in the Bald Mountain limestone in the vicinity of Saratoga Springs.[50] There the limestone lies between the Normanskill and Deepkill slates[51] and according to the most recent correlations represents part of the Beekmantown.[52] This horizon is therefore, probably present in the limestone in the Newburgh quadrangle also. W. B. Dwight also "found a few ill-defined Calciferous fossils in the limestone of this area northeast of Washington lake."[53]

Much of this belt of limestone is drift covered. It outcrops almost continuously, however, along the eastern margin, where it forms a conspicuous cliff, especially along the northern half of its extent, also along the state road between Newburgh and Montgomery, and at the central part of the eastern base of Cronomer hill. The dip of the limestone varies. On the state road west of Newburgh the dip is 12° east, a few hundred feet to the west the angle has increased to 25°. About 2 miles north at the base of Cronomer hill, Gidneytown creek has cut through and exposed similar fine-grained limestone dipping 20° east. Across the creek and immediately east of the road that parallels the creek at this point, is very much broken limesone dipping 80° to the east. Slightly more than 100 feet of covered ground separates the two outcrops, a distance insufficient to account for such a decided change in dip by folding; it can be easily explained, however, by faulting, especially since the latter explanation is

[47]Gordon, C. E. *Loc. cit.* p. 49.
[48]Ries, H. Geology of Orange County. N. Y. State Museum Rep't 49, 2. 1895. p. 469.
[49]Whitfield, R. P. Amer. Jour. Sci., ser. 3. 1879. p. 227.
[50]Cushing, H. P. & Ruedemann, R. Geology of Saratoga Springs and Vicinity. N. Y. State Mus. Bul. 169. 1914. p. 77.
[51]Cushing, H. P. & Ruedemann, R. *Loc. cit.* p. 80.
[52]Ruedemann, R. Paleontologic Contributions from the New York State Museum. N. Y. State Mus. Bul. 227–28. 1919. p. 129.
[53]Ries, H. *Loc. cit.* p. 444.

Cryptozoon-like markings on the weathered surface of the Wappinger limestones along the Cochecton turnpike west of Newburgh.

strengthened by other evidences, the extreme fracturing of the rock, the position of this spot on a line along which to north and south faulting has taken place, and the swerving of the creek at that point.

Following the belt eastward, we find the drift cover burying the bedrock for about a mile. Near the cliff on the west side of Gidneytown avenue, the dip is to the west.

Figure 5

It is practically impossible to calculate the thickness of the Wappinger limestone in the vicinity of Newburgh though it is no doubt considerable and somewhere between 600 and 800 feet.

Summary. From the foregoing discussion it is evident that the data at hand give little conclusive evidence of the horizons represented in the limestone of the quadrangle. It is decided with some degree of certainty on account of the faunal content, that the Balmville limestone is either uppermost Black River or early Trenton in age. Further than that deductions from probabilities alone are used. The limestone of the Newburgh area seems to be the continuation of the westernmost belt of limestone in Orange county, which has been shown by Gordon to contain fossils of Potsdam and Trenton horizons. Therefore it is probable that the Potsdam is also represented in the Newburgh limestone. This reasoning is strengthened by the observation of a limestone west of Newburgh, that looks very much like the Hoyt limestone of the Upper Cambrian, and contains a Cryptozoon-like marking. In the Poughkeepsie quadrangle the limestone that lies conformably above the Poughquag quartzite is shown by its fauna to belong in the Lower Cambrian. Immediately east of Cronomer hill the limestone is in conformable contact with the Poughquag, and is considered to be Lower Cambrian also. In the continuation of the limestone belt south of the area under study, Whitfield found gastropods which are like those found in the Bald Mountain limestone, that is correlated with some part of the Beekmantown. Therefore the Wappinger limestone of the Newburgh quadrangle, including the Balmville member at the top, is considered to represent horizons in the Lower and Upper Cambrian, Beekmantown, and uppermost Black River or basal Trenton.

Hudson River Formation

Historical Review. The third major member of the Cambro-Ordovician of northeastern United States consists of a much repeated succession of slaty and sandy shales and thin-bedded grits which underlies not only the entire Newburgh quadrangle, with the exception of the northwestern and southeastern corners, but extends widely both to the north and the south. Since 1840,[54] the slates and sandstones along the Hudson river have been known as the Hudson River Slate group or some slight variation of that term, but so have other formations not in the Hudson valley, as for instance, the shales in western New York,[55] in Missouri,[56] in Wisconsin,[57] and in Canada.[58] When later more detailed examination of these strata showed that they were not of the same age, and were therefore not to be correlated or to be designated by the same name, much confusion arose, partly because of the already widespread use of the term in geologic literature, and partly because of the failure of the investigators to agree on the age of certain of these units, and especially of that unit which was the type of Mather's Hudson River group. Indeed, even today, the horizon of the shales along the Hudson river north of the Highlands is known only in those localities which have been the subject of particular study. It is evident, consequently, that the question of the age of the Hudson River beds, by which is meant the slate and sandstone strata overlying the Cambro-Ordovician limestones (commonly known as Wappinger) in the valley of the Hudson river, is not yet settled, and is in fact so little understood that an attempt to state the facts again will not be out of place.

The broad belt of shales with interbedded sandstones upon which is developed the extensive valley of the Hudson river was among the first geologic units noticed by the pioneers in American geology. In 1817 William Maclure[59] wrote "From Philiptown on the Hudson to near Lake Champlain, is a strip of transition from 15 to 25 miles wide on the east side of the Hudson, and extending on the west side perhaps further." At the same time Amos Eaton[60] was writing

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[54]Mather, W. W. Fourth Annual Report, State of New York, In Assembly No. 50. 1840. p. 212.

[55]Hall, James. Geology of New York. Part IV. 1843.

[56]Rowley, R. R. Geology of Pike County, Mo. Bureau Geology and Mines, 2d ser., v. VIII. 1907.

[57]Chamberlin, T. R. Geology of Wisconsin. v. I, 1873–79. p. 145.

[58]Adams and Leroy, Canadian Geological Survey, Ann. Rep't v. 14. 1904. p. 220.

[59]Maclure, William. Observations on the Geology of the United States of America. 1817. p. 97.

about "the transition argillite," soft, slaty, homogeneous bluish or dark brown rock, which forms the basis of more than 2000 square miles in New York State, and which is well seen on the banks of the Hudson. Many were the references during the middle part of the nineteenth century to these "slates and graywackes" as members of the Ancient Transition class,—that class lying above the primitive rocks and containing "the first organic remains."

With the inception of New York's First Geologic Survey in 1836 began the detailed examination of these rocks. In 1837, W. W. Mather,[61] geologist of the first district, which included the southeastern part of the State, published his first report, a general areal reconnaissance, in which he mentions "the slates of the Hudson river" as an economic resource. In the third annual report[62] the slate and graywacke region of Orange county is noted, and in the appendix[63] appears the first detailed study of the geology of Orange county and consequently of the shales so abundantly developed there.

In the report for the following year, Mather[64] proposes the name "Hudson River Slate group." He says:

> The lowest in the series (fossiliferous series of rocks) is the Hudson River slate group, consisting of slates, shales, and grits, with interstratified limestones, all of which occur under various modifications. This group is overlain unconformably in many places by the various rock formations of more recent origin.

On pages 256 and 257 of the same report appears a somewhat more detailed account of these strata "Hudson Slate Group. This group consists of a series of slates, shales, grits, and limestones, with silicious and calcereous breccias, and hypogene and plutonic rocks." The few fossils found are reported as shell impressions and the graptolites, Fucoides serra (Tetragraptus serra, Deepkill), F. dentatus (Diplograptus dentatus, Deepkill, or D. foliaceous, Normanskill) and probably F. lineatus

[60]Eaton, Amos. An Index to the Geology of the Northern States. 1820. p. 163.
A Geological and Agricultural Survey of the District Adjoining the Erie Canal in the State of New York. 1824. p. 32.

[61]Mather, W. W. Geology of New York. First Annual Report. 1837. p. 61–92.

[62]Mather, W. W. Third Annual Report. State of New York, In Assembly, No. 275. 1839. p. 114.

[63]Horton, W. Appendix B to the Third Geological Report of the First District, State of New York, In Assembly. No. 275. 1839. p. 134-75.

[64]Mather, W. W. Fourth Annual Report, State of New York, In Assembly, No. 50. 1840. p. 212.

and F. ramulosus. "These fucoides or graptolites were in the black shale underlaying the Shawangunk grit, on the mountain about 1½ miles east of Ellenville, at the height of 500 to 700 feet above the valley." Mather says in conclusion:

> The Hudson Slate group corresponds in many respects with the "Cambrian system" of Professor Sedgwick, to which it may be a geological equivalent. It occupies most of the country between the Highlands on the southeast, and the Shawangunk mountains on the northwest, and forms the mass of the latter mountains which are capped, and in some places enveloped by the Shawangunk grit. From Kingston, the Hudson Slate group ranges along the right or western bank of the Hudson to Albany, underlying the superincumbent rocks unconformably, with few exceptions. Its range on the left bank of the Hudson, as far as examined, is detailed in the second annual report on the geological survey of the first district of New York.

From the foregoing it is not possible to determine the age of the Hudson Slate group. The identification of the graptolites is probably not to be relied on; even if we translate the early determinations into present day nomenclature[65] (as suggested in parentheses after each name) the shales in which the graptolites were found are either Deepkill (upper Beekmantown-Chazy) or Normanskill (Chazy-Black River-Trenton),[66] whereas Sedgwick's Cambrian System, with which Mather was inclined to correlate the shales, included the Cambrian and Ordovician as understood today. In 1841 Mather[67] made the important statement that he had "found an entire analogy in fossils of the slates of the Hudson river, in Rensselaer and Saratoga counties, and in the western parts of the State." In much more recent and detailed work in the two counties mentioned by Mather, Ruedemann[68] has determined the shales to be Schenectady, Canajoharie, Snake Hill, Normanskill and Schaghticoke, which are all older than the Utica and Lorraine shales of western New York. From this and other similar mistakes of the earlier geologists has risen all the confusion relative to the age of the Hudson River shales.

While Mather was unravelling the geology of the first district, the other members of New York's first survey were also carrying

[65]Bassler, R. S. Bibliographic Index of American, Ordovician and Silurian Fossils. Smithsonian Institution, U. S. Nat. Mus. Bul. 92. 1915.

[66]Ruedemann, R. Museum Memoir 7. 1905.
Museum Memoir 11. 1908.
N. Y. State Mus. Bul. 227–28. 1921. p. 130.

[67]Mather, W. W. Amer. Jour. Sci. 41:164. 1841.

[68]Ruedemann, Rudolf. N. Y. State Mus. Bul. 162. 1912.
N. Y. State Mus. Bul. 169. 1914.

forward their observations. Ebenezer Emmons,[69] geologist of the second district, says in his report, "this mass (grey sandstone, Lorraine of Jefferson county) appears from its position to be equivalent to the greywacke in the Hudson River series."

For the shales in the third district, Vanuxem[70] also accepted the name Hudson River. He says:

Hudson River Group. This group consists of the Frankfort slate and sandstone, and the sandstone shale of Pulaski, or shales and sandstones of that place. The group rests upon the Utica slate throughout the district, and is next in order of age. It is followed by the gray sandstone of Oswego, the rock which immediately succeeds to it in the district where the rock exists. The name is adopted as being generally used in the survey, and as being more comprehensive than the one heretofore used. It is, however, objectionable, from the difficulty of defining its limits along the region of the Hudson river; from the disturbed and altered state of the greater part of its rocks; from the absence of those which immediately precede and follow it, and which show its position in the class; and from the difficulty of separating or distinguishing the slaty or schistose members of the group, from those of greater age with which, on their eastern border, the two are more or less really or apparently blended. These objections are of no small import. The difficulty of the subject had led other geologists into error, besides those of our country.

Indeed, Vanuxem's statement of the difficulties in "Hudson River" determination is just as clear and the objections are as valid today as they were in 1842.

Hall[71] also extended the term to the rocks between the Utica slate and grey sandstone of the fourth district of the state. He says:

Hudson River Group. Where the strata are undisturbed, a well-marked line of division usually separates this group from the Utica slate; but along the Hudson river, and in other places where the disturbance has prevailed, the two are not easily separable. Indeed, from the fact that several fossils of the Trenton rocks are continued through the Utica slate, and appear in this group, we might almost be inclined to consider it as a continuation of the same; beginning with a shaly limestone, and passing through shale and shaly sandstone to the termination of the series.

Hall[72] thus considered that both Utica and overlying Hudson River beds were present in the Hudson valley. From his lists of

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[69]Emmons, Ebenezer. Geology of New York, pt II. 1842. p. 406.
[70]Vanuxem, Lardner. Geology of New York, pt III 1842. p. 60.
[71]Hall, James. Geology of New York, pt IV. 1843. p. 18.

characteristic fossils, however, it is seen that none are found in the Hudson valley. Hall himself realized the difficulties in distinguishing these shales, even with the aid of fossils. In a note to a table of species, including those occurring in the Utica slate and in the Hudson River group, he[73] says:

Several species of Graptolithus are marked as occurring in the shales of the Hudson River group only. These are unknown to me in any situations, except where the strata are so much disturbed as to render it difficult to identify the Utica slate, in the absence of other fossils; and it is quite possible that the black slate containing them is that rock, interplicated and folded with the green slates and shaly sandstones, which latter, in undisturbed regions, constitute the Hudson River group proper.

Later Hall[74] made the Hudson River include "all the beds from the Trenton limestone to the Shawangunk conglomerate." Still further study and comparison of formations and faunas caused him to change his views, and in 1862[75] he advocated dropping the term "Hudson River," because he then agreed with the Canadian geologists upon the correlation of the Point Levis and Hudson River shales. By 1877, however, Hall[76] had returned to his earlier opinion that "The term 'Hudson River group' has therefore a definite significance . . . ." and that "these rocks (Cincinnati group) are of the same age and hold the same geological position between the Trenton limestone below and the Clinton or Niagara group above, as the rocks of the Hudson River group in the original significance of the term."[77]

The work of Hall, Vanuxem, Emmons and Mather, geologists of New York's first survey, was summarized in the great 1843 report.[78] By their work was established the New York System,[79] in which the lowest division was called Champlain, and was equivalent to the rocks included in the annual reports of the first geological district under the name of Hudson River slate series and Hudson Slate

[72] *Loc. cit.* p. 30.
[73] Hall, James. Natural History of New York, pt VI, Paleontology. v. 1. 1843. p. 329.
[74] Hall, James. Paleontology of New York, v. 3. 1859. p. 14.
[75] Hall, James. Geological Report of Wisconsin. 1862. Footnote to p. 47.
[76] Hall, James. Proc. of Amer. Assn Adv. Sci. 1877. p. 259–65. Note upon the History and Value of the Term Hudson River Group in American Geological Nomenclature.
[77] Mather, W. W. *Loc. cit.* p. 263.
[78] Mather, W. W. Natural History of New York. Geology, pt I. 1843.
[79] *Loc. cit.* p. 2.

group.[80] On page 367 of the same report is given in tabular form the assumed synonyms of Hudson River group "used in the geological reports of the states and in Eaton's Geology."

Hudson River Group	Frankfort slate group; Frankfort slate and rubblestone; green slate and rubblestone; Pulaski shales; Graywacke, G. slate, G. shale, Slaty graywacke and Transition argillite of the Annual Geological Reports; Graywacke and metaliferous graywacke of Eaton. No. 3 of the Pennsylvania survey.

From this it is evident that great uncertainty existed as to the age of the shales in the Hudson valley; the reasons for this uncertainty have already been set forth. Whatever may have been the cause, we know that the term "Hudson River group" had become the large general term used almost all over North America for the Lorraine or Cincinnati divisions of the Upper Ordovician.

It is not in recent years only that the mistakes made in the determination of the age of the shales along the Hudson valley were recognized, or the fallacies of correlating with them other doubtful formations of distant areas. James Hall several times changed his views on the equivalency of these beds.[81] Finally in 1877[82] he thought it advisable to review the whole subject. These are his conclusions: The term "Hudson River" has a definite significance, and applies to the shales in disturbed condition in the Hudson valley and the equivalent nearly horizontal rocks in western New York.

The keen-minded F. B. Meek[83] stated the facts most lucidly as follows:

In the introduction to the Illinois Paleontology, just published, Mr Worthen and the writer have some remarks on the impropriety of transferring the name *Hudson River group*, from the older series of contorted slates and argillaceous sandstones to which it was originally applied (existing in great force along the stream above the Highlands), to the more modern group composed of the *Lorraine shales*, Frankfort slates, etc., with which the true Hudson River rocks were subsequently confounded.

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[80] Mather, W. W. *Loc. cit.* p. 366.

[81] Ruedemann, Rudolf. Hudson River Beds near Albany and their Taxonomic Equivalents. N. Y. State Mus. Bul. 42. 1901. p. 493–96.

[82] Hall, James. Note upon the History and Value of the Term Hudson River Group in American Geological Nomenclature. Proc. Amer. Ass'n Adv. Sci. 1877. p. 26, 259–65.

[83] Meek, F. B. Amer. Jour. of Sci. and Arts. 43:256-57. 1867. Note on the use of the name " Hudson River group."

Since these remarks were in print, I observe we were in error in supposing that late investigations had brought to light facts casting doubt upon the occurrence of the later types of fossils along *any* part of the Hudson river, in other than the little isolated masses alluded to as occupying synclinal axes in the older rocks, or entangled amongst their contorted strata. The fact, however, that the more modern types of fossils are not known to occur under other circumstances than those mentioned, along the part of that stream regarded as the *typical localities of the Hudson River group* and lying mainly between the Highlands and the region of Albany, while the name, as originally used by Conrad and Mather, was expressly applied by them to this older series, which they regarded as belonging to the Cambrian of Sedgwick, is believed to be a sufficient reason for objecting to the transfer of the name to the later group. Hence if retained at all, it is believed this name should be applied exclusively to the group of rocks for which it was originally intended, and to which it must always carry the minds of those who may look into its origin and history. As it, however, subsequently became very generally also associated with the more recent series already alluded to, it probably could not now be restricted without much inconvenience, to the rocks to which it properly belongs. Consequently the surest, if not the only way to avoid confusion, will be to strike it entirely from our nomenclature. The name applied to the more recent rocks, in Mr Worthen's report on Illinois, is the Cincinnati group, from the great development and highly fossiliferous character of these beds at the well-known city of that name in Ohio.

About this time Whitfield[84] recognized the composite character of the Hudson River beds. He inferred from the evidence of fossils that some of the shales south of Troy were equivalents of the Trenton limestone and that the Normanskill was to be correlated with the Utica.[85]

It is apparent, then, that the more detailed study of the shales in the Hudson valley continued to cast doubt on the correlations previously made. The views of the geologists changed rapidly. In 1889 Walcott[86] presented a very careful resumé of the term and reached the following conclusions:[87]

1 The series of rocks under consideration had at various times been called Salmon River, Conrad, 1836; Hudson River, Mather, 1840; Lorraine, Emmons, 1842; Nashville, Safford, 1853; Cincinnati, Meek and Worthen, 1866; Maquoketa, White, 1870.

84 Ruedemann, Rudolf. N. Y. State Mus. Bul. 42. 1901. p. 496–98.

85 Whitfield, R. P. G. M. Wheeler's Rep't on Survey West of 100 Meridian. Paleontology, v. IV. 1877. p. 19–20.

86 Walcott, C. D. The Value of the Term "Hudson River Group" in Geologic Nomenclature Bul. Geol. Soc. Amer. 1:335–56. 1890.

87 Walcott, C. D. *Loc. cit.* p. 344.

2 The term "Hudson" should be retained for the series of strata between the Trenton limestone and the superjacent Upper Silurian rocks.

3 The sections in the Hudson valley embrace all the strata between the Trenton limestone and the Upper Silurian. Although as far as is known the typical fauna of the upper series is absent from the valley of the Hudson, this does not injure the correlation.

4 The term "Hudson" should be adopted for the whole series and not replace any of the local names. Thus each of the following formations, Hudson River shales and grits, Utica shale, Frankfort shale, Lorraine shale and sandstone, Salmon River sandstone and shale, Cincinnati shale and limestone, Nashville shale, and Maquoketa shale, belong to the Hudson terrane, and represent it in certain localities.[88]

Further investigations have proved the invalidity of Walcott's conclusions. Ruedemann's careful studies of the Ordovician shales in eastern New York have given us an appreciation of the true significance of the term "Hudson River." At first he[89] assumed the presence of Trenton, Utica, and Lorraine shales in the Hudson River beds near Albany. Further investigations[90] have led him to decide that the shales identified as Utica and Lorraine are really of earlier age and lie below the Utica. As a result of such determinations, the New York State Geological Survey has dropped from use the term "Hudson River group."[91]

Many details relevant to a discussion of the usage and significance of this term have been omitted here, since in articles referred to above, Walcott, Ruedemann and others have treated them more completely.

In the light of much further field work and correlation in the great series of shales overlying the lower Ordovician limestones throughout a large area of the state of New York, it was deemed necessary to abolish the use of the term "Hudson River group" or series for these shales. The inevitably incomplete observations and studies of the earlier New York geologists had led to a much too

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[88] Walcott, C. D. *Loc. cit.* p. 352–53.

[89] Ruedemann, Rudolf. Hudson River Beds near Albany and Their Taxonomic Equivalents. N. Y. State. Mus. Bul. 42. 1901.

[90] Ruedemann, Rudolf. Lower Siluric Shales of the Mohawk Valley. N. Y. State Mus. Bul. 162. 1912. p. 59.
Geology of Saratoga Springs and Vicinity. N. Y. State Mus. Bul. 169. 1914.
Communications to the writer.

[91] Hartnagel, C. A. N. Y. State Mus. Handbook 19, 1912. Classification of the Geologic Formations of the State of New York.

ambiguous and too broad application of the term, which as used in reports on different portions of North America came to indicate any part of or even the entire Ordovician system. This resulted from the misconception of the geologic range of the shales that extend along both sides of the Hudson river north of the Highlands. Since it was to these rocks, however, that the term was first applied, it seems still proper to speak of them as Hudson River, as long as it is borne in mind that it is a locality designation for the shales of the Hudson valley. Except for formations equivalent in age to the shales of the Hudson valley, the term can have no significance whatever, and "as a term for upper Ordovician strata overlying the Utica the name 'Hudson River' is entirely inappropriate, and no excuse exists for its further retention with that significance."[92]

It appears from a careful study of the literature relative to the term "Hudson River Group,"

1 That Mather had a definite and well-defined series to which he gave the name.

2 That the major lithologic characters of this series along the Hudson river were common also to shales which outcrop over other large areas of New York State.

3 That for these shale units was adopted the name first applied to rocks of similar lithology along the Hudson river.

4 That the rocks of this character which outcrop to the west were of simpler structural relations and were therefore more readily and more accurately placed in the stratigraphic series than those to the east.

5 That the correlation given the shale facies in western and central New York was eventually accepted and applied to the comparable series in eastern New York.

6 That in this manner the age determined for certain shales on the grounds of fossil content and stratigraphic position in the western part of the State was also adopted for widely separated occurrences of formations of similar lithologic peculiarities; or more specifically that the term "Hudson River," which name originally defined rock of Trenton and possibly older age along the Hudson valley, was used for similar formations in western New York, where the age of the beds was definitely upper Ordovician; and, since the intensely disturbed character of the Hudson River beds

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[92] Foerste, A. F. Upper Ordovician Formations of Ontario and Quebec. Canada Dep't of Mines, Geol. Survey Memoir 83, no. 70. Geol. Series. 1916.

as first defined caused much confusion and difference of opinion as to their true age, the correlation of the western more easily determind formations came to be adopted for the Hudson valley series.

In general, however, it seems that the broad usage of the term has been well justified. The term originally defined a facies, not a horizon and meant not rocks of Trenton or of Cincinnati age, but the series of slates, shales, grits and occasional limestones, which in eastern New York is lowest Ordovician, or possibly even Cambrian, and which rises gradually in the stratigraphic column toward the west so that finally in western New York the age is upper Ordovician. It is a normal transgression of a clastic facies advancing in age with distance from the source of supply.

It is evident after following the shifting trend of usage that Mather, in whose district this series is best developed and where to this day no other term is so suitable, accepted the more accurate stratigraphic determinations made by his associates farther to the west. Thus the term "Hudson River" came to be regarded as of Cincinnatian age, whereas these rocks along the Hudson river itself, where the name originated and where, if anywhere, the name should still apply, are certainly older.

This difficulty in age correlation in the different occurrences of the shale series led finally to the decision to abandon the name entirely. This, considering the whole situation, may be justified on purely stratigraphic grounds, but on structural grounds it is neither practicable nor desirable in the type region. Clarke and Schuchert say:

It is becoming increasingly evident that the great mass of shale in the Mohawk and Hudson river valleys which was designated at an early date by this term is resolvable into horizons extending from the middle Trenton to and including the Lorraine beds. At present it seems unlikely that when this determination of horizons has been carried through the series any part will remain to which the original term can be applied by virtue of its distinctive fauna, though it may still serve to designate a facies of the formations mentioned.

It is eminently impracticable in a formation of such structural complexity that neither its thickness can be determined, nor its different members can be arranged in sequence, and in a formation of such faunal poverty that the niceties of horizon correlation can not be made, to insist on an age or stratigraphic designation.

The practical and useful thing in the long run is to adopt a designation either descriptive of its petrographic habit or of its field occurrence, because this will be done of necessity by everyone who works in this field.

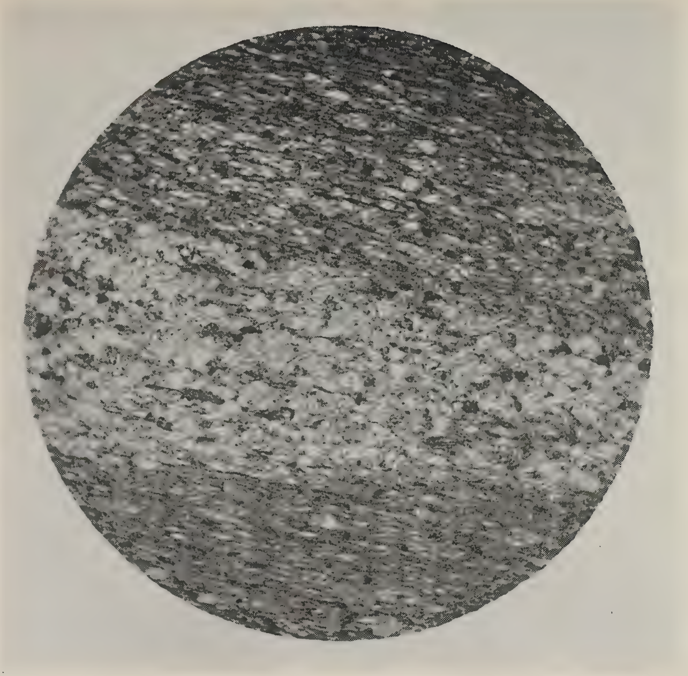
For these reasons chiefly and because stratigraphic refinements on a faunal basis have not yet been fully worked out in this southern extension of these homogeneous beds, we find it necessary to return as a temporary expedient, to the historic term. The Hudson River formation includes the whole complex series of shales, slates, sandstones, graywackes and associated beds of whatever variety, lying between the Wappinger limestone and the Shawangunk grit.

Lithologic character. The bed rock of practically the entire lowland area of the Newburgh sheet consists of an exceptionally monotonous succession of shaly and sandy slates and graywackes. Except in the cases of the few heavy sandstone beds, any one layer or series of layers can not again be recognized from its lithological character, even along the strike. Across the dip not once was a layer seen to be repeated by folding or faulting, and yet all other observations and deductions lead to the conclusion that manifold repetitions do occur. Most striking is the ever-varying appearance of the beds; every gradation between and combination of slate, shale, graywacke and conglomerate, have been observed and also a calcareous facies which, though never producing a layer of limestone, is represented by the high carbonate content of some beds. The prevailing color is dark bluish or greenish gray; only the weathered surface of the limey facies deviates much from this slate color, and is a dark rusty brown.

The gradations between the main types of sediments in the Hudson River group are infinite, and no attempt will be made to describe any but the more distinctive facies. This will be done with reference to localities at which each type is especially well developed.

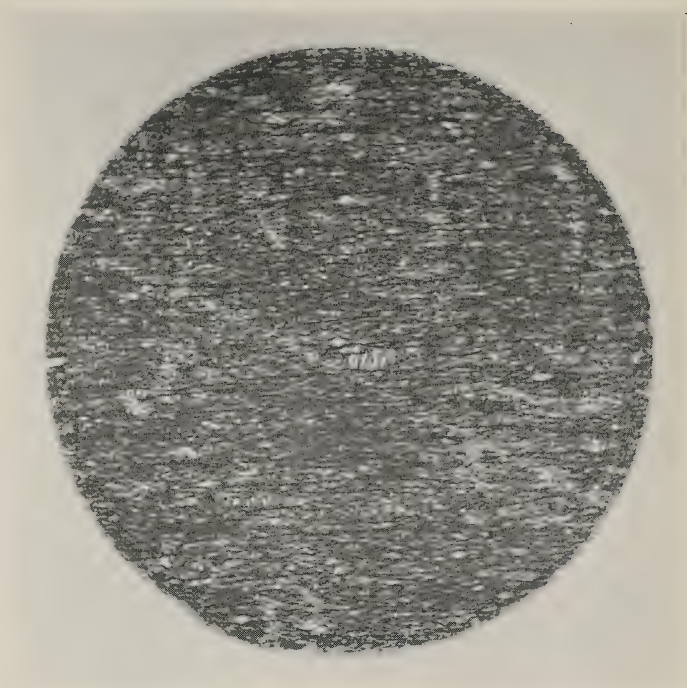
1 *Shaly slate with fine siliceous laminations.* The hill which rises to an elevation of 440 feet west of Balmville consists entirely of grayish black carbonaceous shale which weathers to small angular chips. Closely spaced bedding planes together with jointing give the rock so many lines of incipient weaknesses that it becomes almost "rotten" upon exposure, and no determination of bedding is possible. The road that skirts this hill on the north has exposed in places less weathered, and therefore more massive, outcrops. Hand specimens show numerous thin sandy laminae, weathering yellowish brown and contrasting with the blue gray of the remainder of the rock. In thin section (plate 18) it is a fine-grained fragmental rock, in which the larger grains are almost entirely quartz and show a tendency to orientation parallel to their longer directions. Some of the finer

Plate 18



Photomicrograph of the siliceous slate of the Hudson River formation, from the north side of the hill (440′) between Cronomer Hill and Balmville. No. 10–29. Taken in plain light, magnification 45 diameters. A fine-grained fragmental rock, in which the larger granules are almost entirely quartz. Through the center of the photomicrograph extends a sandy layer. The dark patches show the very fine grained cement, consisting largely of carbonaceous, micaceous and limonitic material.

Plate 19



Photomicrograph of slate of the Hudson River formation, from ½ mile west of Fostertown. No. 5–27. Taken in ordinary light, magnification 45 diameters. This specimen is similar to the preceding one, but shows a more typical slate. It is finer textured and has the mica flakes more largely developed.

Plate 20

A cut in Hudson River slates at the eastern base of King's Hill. Slatey cleavage is typically developed at an angle of about 30 degrees to the bedding planes.

granules are feldspar, mica, zircon and magnetite. The base is exceedingly fine-grained, consisting of carbonaceous matter and the alteration derivatives from original feldspar and ferromagnesian minerals, and includes kaolin, quartz, sericite, carbonate and limonite, and probably also epidote and zircon. The lighter colored band through the center of the photomicrograph is a gritty lamina; the darker portions are slate. Sandy admixture increases in some beds giving a sandstone with excessively thin shale laminae. A slate with little sand admixture outcrops west of Forstertown. It is almost a phyllite in hand specimen, and under the microscope (plate 19) displays so fine-grained a texture that few of the constituents can be determined with certainty. Tiny quartz granules are in greatest quantity; mica flakes are abundant, and lie with their longer axes parallel. The denser streaks contain carbonaceous material, limonite, epidote and zircon.

2 *Alternating slate and more massive sandy beds, the former predominating.* One of the best and most continuous exposures was opened between Rock Cut and Stony Brook farm along the electric trolley line connecting Newburgh and Walden. The slate beds are from ½ inch to 6 inches thick, and appear fairly massive until weathered or broken, when the secondary cleavage, developed very constantly at an angle of about 30° to the bedding, becomes marked, and the slate breaks into moderate sized chips 1 to 2 inches long. Often the breaking develops cleavage rhombs. The sandstone layers are massive and vary from 6 to 18 inches in thickness. Sometimes pockety lenses of very thin slate (paper shale) separate the sandstone beds, which are often most delicately cross-bedded, showing swiftly changing current action. Some thin layers contain weathered pyrite nodules. These beds dip 12° east and strike north 15° east. At the east base of King's hill is an exposure of rock of similar type. Here thin sandstone beds, averaging about an inch in thickness separate slate layers three or four times as thick. The slaty cleavage is most perfectly developed at 30° to the bedding plane (plate 20). The lower portion of the face of the Shawangunk mountains consists of fissile splintery shale, which on the talus heaps looks like small shavings of wood, and these slate beds are separated by cross-bedded sandstone beds ½ inch to 6 inches thick. On the state road connecting Newburgh and Montgomery is an outcrop of slate and subordinate sandstones, dipping 40° east, striking north 15° east. The sandstone beds are 2 to 4 inches thick.

3 *Alternating sandstones sand slates, sandstones predominating.* The Breakneck ridge quarry, which was a large source of supply

for the "fill" of the Catskill aqueduct in the vicinity, exposes 50 feet or more of massive sandstones, ranging from 8 or 9 inches to several feet in thickness, and separated by fine black shale layers from 2 inches to 2 feet thick, (plate 21). All the layers show current action, the sandstones by very fine cross-bedding, the shales by the beautiful development of tiny, sandy lenses, as if there had been a minute oscillation back and forth from deposition of mud to deposition of fine sand. The sandstone is dark bluish gray and appears firm and well cemented. In thin section (plate 22) it is seen to consist chiefly of quartz grains, irregular in shape and size, varying in diameter from .02 to .5 mm. A few of the quartz grains show strain effects, such as wavy extinction, a character inherited from the old igneous and metamorphic rocks from which the Hudson River formation was derived. A small percentage of the grains is made up of fragments of different rocks, of plagioclase feldspar (about oligoclase-andesine), and of calcite. Incipient anamorphism, showing in the development of carbonate, chlorite, silica and limonite from the original argillaceous binding material, has gone so far as to attack the margins of the grains and to produce the crenulate borders and slightly interlocking habit of the quartz fragments. This has resulted in a strongly cemented rock.

4 *Graywackes.* The Marlboro mountains owe their height to the massive character of the constituting strata. In the cut at the northern end just west of Highland are fine exposures of the sandstone, showing them to be medium to coarse-grained and thin-bedded, an average bed being less than a foot thick. In places the graywacke is conglomeratic, and infrequently intercalated shales occur. These beds, east of Lloyd, are dipping 32° east; they strike north 20° east. Usually, however, the dip is steeper, ranging from 30° to 80°. Because of its high carbonate content the graywacke is rather easily weathered, and a rim of reddish brown, porous rock often extends a half inch into the rock from an exposed surface. When fresh, it is very dark bluish gray. Plate 23 is a photomicrograph of graywacke from the western margain of the region, from the hill under "Cra" of "Crawford." It shows a moderately coarse, fragmental rock, in which most of the grains are quartz; simple or composite grains of clear quartz of igneous origin predominate, but some are vein quartz, and some owe their present outline to secondary enlargement. Other grains are lithic fragments, representing, among other older rocks, graywacke, fine grit, shale, schist, quartzite, chert, dolomite, and fine and moderately coarse limestones, one of these showing in the wavy control

Plate 21

Large cut in the Hudson River formation on the west side of Breakneck mountain. The characteristic alternation of sandy and slaty beds is well shown.

of the carbonate a fossil fragment. Still other grains are of the minerals magnetite, microcline, perthite, oligoclase-andesine, zircon and calcite. The feldspars are fresh and many of the grains are strikingly angular. Both these facts corroborate the theory of the derivation of the Hudson River formation from older rocks not far distant. The feldspar fragments indicate a source in the granites that invaded the old metamorphosed sediment, from which, and also from later less modified sediments, came the lithic grains. The binder is a complex aggregate, consisting of calcite, sericite, chlorite, limonite, leucoxene and magnetite. The graywacke has been slightly fractured and healed with carbonate.

5 *Graywacke conglomerate.* Among the graywackes and slates of the Marlboro mountains occurs a peculiar conglomeratic facies; in it subangular and rounded fragments of shale, sandstone, graywacke, limestone and green and black chert, whose source is in the underlying Ordovician rocks, are firmly cemented into a hard, tough rock. The larger fragments, and these are all rock fragments, vary from ¼ inch to 2½ inches in length, and lie, for the most part, with their longer dimensions parallel. The binding material is a coarse graywacke, in which tiny quartz pebbles and sand grains predominate, but in which there are small fragments of the same materials as are present in the pebbles, and much interstitial carbonate, so that the graywacke portion effervesces slightly with acid. Under the microscope no two fields are similar. Plate 24 shows a photomicrograph of one field which includes part of one of the large pebbles of fine grained closely laminated limestone. The undulating lines of deposition are evident. The balance of the field is graywacke; quartz grains, some exhibiting strain effects and some showing slight secondary enlargement, which has resulted in the very irregular margins, and lithic grains are bound together with a complex cement, predominatingly carbonate and silica. Many of the grains can be seen both in megascopic and microscopic examination to have been fractured and healed by infiltration of the finer cement materials.

Minor structures. A very constant structure in the Hudson River formation is the slaty cleavage, so regularly developed throughout the finer grained beds that slate is believed to be present in much greater quantity than is shale, and even more than is graywacke. In all the mud rocks except those containing much sand, either in the form of frequent tiny lenses or laminae, or just distributed through the bed, a secondary cleavage is very perfectly developed, often at

an angle of about 30° with the bedding planes (plate 20). Many of the fine-grained rocks seems to be shale until they are broken, when the slaty cleavage becomes obvious.

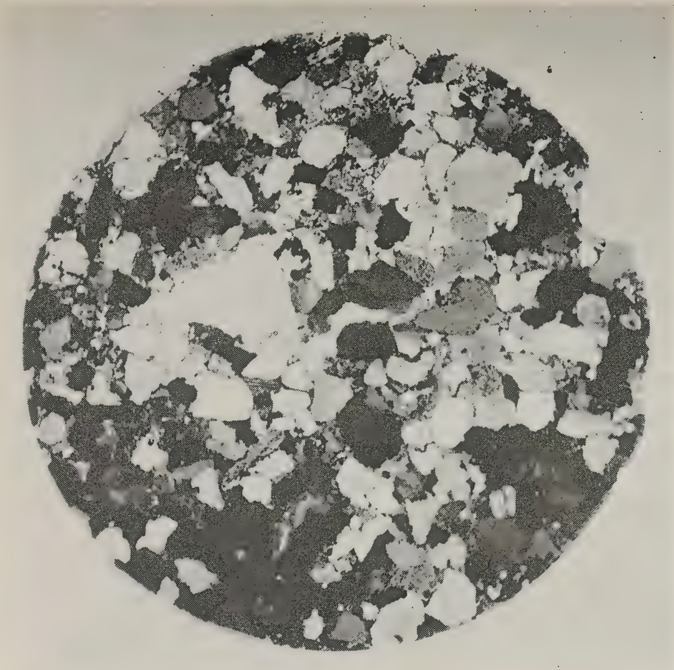
Cross-bedding is extremely common in these rocks, and is particularly noticeable after weathering, when because of slight differences in composition, the tiny laminae stand out in corrugations (caudagalli weathering) or in varying colors. Thus in the black slates the tiny sandy lenses appear brown and reddish, and in the sandy beds fine black stringers of mud are contrasted with the brownish gray graywacke. Ripple and rill marks are also preserved. Weathering discovers many other minor structures. Near the base of the front range of the Shawangunk mountains layers of slate seem to be covered with very small mud cracks. On closer examination the mud cracks are seen to be incipient joint planes, or other lines of weakness, along which the rock breaks easily and irregularly into fragments less than a half-inch in diameter. Not far away the joint planes are more distantly and regularly spaced, so that a cliff at one side of the road is at first glance believed to be protected by a thin masonry wall, made up of slate colored bricks.

Some of the weathered slate looks like chips of dry wood. Some breaks into long slender fragments, some into cleavage rhombs, some into irregular small thin plates. One cliff of slate appears to have been white-washed in imitation of a tiled wall. The solvent and precipitating properties of water circulating along joint and bedding planes are thought to account for this unusual effect. The "whitewash" is carbonate. The coarser grained calcareous rock becomes porous when exposed to the leaching power of water, and weathered surfaces of the graywacke conglomerate contain holes as wide as 2½ inches.

On the hill rising to an elevation of 440 feet west of the Dwaarkill heavy graywacke beds are separated by black slates. The surfaces of several of the graywacke layers are smooth and undulating, as if the still plastic sandy material had flowed, in a manner of subaqueous creep. A low outcrop in the northeast corner of the crossroads at Leptondale shows similar subaqueous solifluction (plate 25).

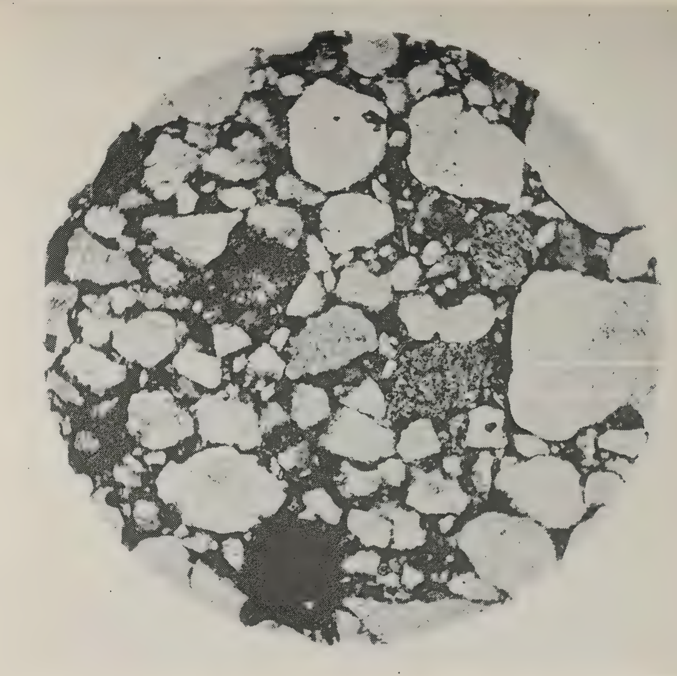
Jointing is no doubt well developed in the Hudson River beds, but is generally not apparent owing to the extremely close spacing of other lines of weakness, mainly planes of cleavage. It is well exhibited, none the less, in the quarry on the north side of the Newburgh-Montgomery turnpike at East Coldenham. There a promi-

Plate 22



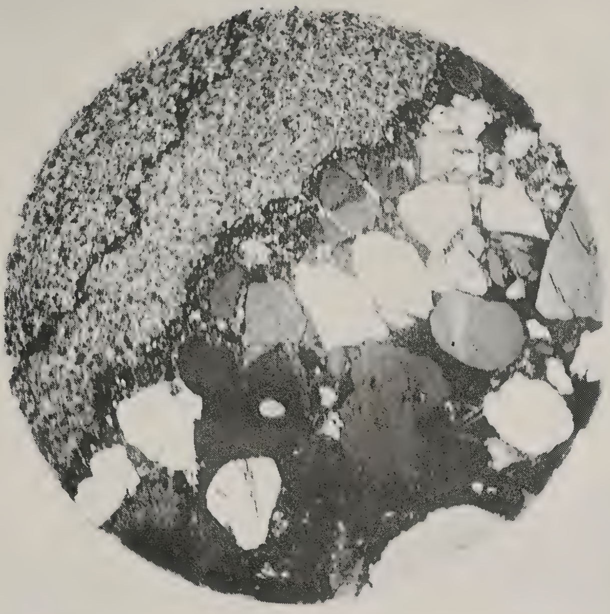
Photomicrograph of a sandstone of the Hudson River formation, from the southwestern base of Breakneck hill. No. 7–15. Taken with crossed nicols, magnification 25 diameters. Very apparent is the poor sorting of the material and the predominance of quartz grains. A few feldspar grains are recognized by the twinning bands; a few grains are fragments of older rock; others are calcite. Note the strain shadows and slightly interlocking habit of the quartz grains.

Plate 23



Photomicrograph of a graywacke of the Hudson River formation, from the hill at the extreme western margin of the quadrangle, west of Allard Corners. No. 4–14. Taken with ordinary light, magnification 25 diameters. It is a coarse fragmental rock with much interstitial material, which is a complex aggregate of carbonate and the secondary derivatives of the original feldspar and ferromagnesian constituents, and is black in the photograph. The clear colorless grains are quartz; the mottled grains are lithic fragments, the small black ones magnetite. Many other mineral grains occur in the rock, but are not visible in this photograph.

Plate 24



Photomicrograph of a graywacke conglomerate of the Hudson River formation, from the gap through the Marlboro mountains about 2½ miles north of Latintown. No. 11–39. Taken with crossed nicols, magnification 25 diameters. The large area of grayish mottled material is part of a fragment of fine-grained limestone, in which the lines of sedimentation are evident. The remainder of the section in the photograph is graywacke with a very calcareous cement.

Plate 25

Mud flow in the Hudson rocks north of Leptondale. The surface has been smoothed and striated by the ice.

nent system of joints, striking about north 30° west, intersects the gentle east dip and the strike of north 15° east.

Origin and interpretation of the Hudson River beds. The exceptionally fine and constant intercalation of sand and mud in the Hudson River beds indicates strong swiftly changing currents with rapid deposition when the currents brought sand, with slow accumulation of mud when the currents subsided. Ripple and rill marks show how the surface of the already deposited mud and sand was scoured by the moving waters. The rock waste that was being heaped up in the relatively deep muddy water, too muddy perhaps for abundant life, came from the weathering of old metamorphosed sediments and the igneous rocks that intruded them. Accumulation was fairly rapid near shore where the coarser materials were dropped, much slower further out where the finest sand and mud gradually settled out of suspension. The coarsest materials, dropped near shore (the western shore of Appalachia), gradually filled in the shallow margin belt, so that later the coarser debris was carried further into the trough, and settled upon the fine muds of the preceding deposition. Thus the deeper portion of the trough was shifted westward, and the products of rock-weathering were carried further westward, so that whereas the rocks of this origin in the Hudson valley of southeastern New York are probably lower and middle Trenton in age, those in Western New York belong to the upper Trenton. The phase known as the Hudson River formation was first deposited near the eastern margin of the sea that covered the Appalachian trough, and becomes progressively younger with distance from Appalachia.

Fragments of many different rock species are visible in a careful examination of the coarser of these sediments, the graywackes. Most of the so-called sandstones of the Hudson River series are more properly graywackes because they contain a large proportion of rock fragments, and are not almost entirely composed of grains of the one mineral, quartz. Quartz predominates, subrounded grains that may be clear vein quartz, or quartz aggregates from some older rock. Other constituents are feldspars of many species, which are strikingly like the feldspars of the old crystalline rocks still existing today, fragments of other minerals of these old rocks, of tourmaline, zircon, apatite and fragments of many rocks. Among those recognized are schist, shale, quartzite, chert and several different limestones. Together with the finer rock waste, clay and

colloidal matters, these might come from the disintegration of a rock such as the Precambrian or modified Grenville as it exists in the Highlands of the Hudson and Adirondacks today. All of this material has been sufficiently sorted, reworked and incipiently anamorphosed to make a compact resistant rock.

The detailed study of the rock of this formation is the problem of sedimentation, an endless diversity of conditions that made possible the bringing together of fragments of many different rocks and of many sizes, and their deposition under the domination of current action. In every locality the constituents vary repeatedly from prevailing clay to prevailing quartz sand.

Distribution of slates and sandstones. It can not be stated for this district as has been done for the larger Hudson valley area which includes it, that in the alternation of sandy and slaty beds, the former become more prominent as the Shawangunk mountains are approached,[93] or as higher horizons in the formation are reached.[94]

From observations in this rather limited district the conclusion has been drawn that there is practically no difference in the distribution of the sandstone beds over large areas. Slates are much more prominent than sandstones near the base of the Shawangunk mountains; the heavy sandstones of the Marlboro mountains are not repeated elsewhere in the quadrangle; but a prominent ridge near the Shawangunk mountains (west of the Dwaarkill) consists of grayish black shales with many heavy sandstone beds, and the lower land east of the Marlboro mountains is prevailingly slate. Not only are the graywackes and sandstones rather evenly distributed, but they are commoner than has been considered heretofore. In scarcely one outcrop are sandy layers absent, and many of the shaly beds are very sandy or contain tiny sand lenses in great numbers. This repetition of lithological facies across the quadrangle is the result of repetition by folding.

Correlation of the Hudson River terrane. The exact correlation of the great mass of the siliceous sediments in the Hudson valley has been a problem since the time of the first geological survey of New York State, whose members failed to realize the fact that all the rocks are not of the same age, and that only after the most detailed observations have been made in each locality can the age

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[93] Mather, W. W. Natural History of New York. Geology, pt I. 1843. p. 371.

[94] Berkey, C. P. N. Y. State Mus. Bul. 146. 1911, p. 46.

be determined. Often, even then, there may be doubt as to the exact correlation.

The most surprising fact established by the investigations in the Newburgh quadrangle is that practically the entire belt of the formations there, some 16 miles in breadth, is to be correlated with a relatively limited horizon of the series as developed in the Hudson valley to the north. The chief object of the study of the area was to obtain a subdivision of the Hudson River formation to give a basis for correlation; for it was argued that in the extremely broad belt of the formation that covers so large a part of the district, there was no doubt a comparatively full representation of the shales of the Hudson valley. This expectation has not been realized in the least. Although the possibility of error is great on account of the omnipresent and obscuring drift cover, every observation leads to the conclusion that one horizon only, that called by Ruedemann[95] the Snake Hill beds, is present. Both faunal and lithologic similarity tend to prove this premise.

The fauna is a very meager one, nevertheless fossils of a few of the species, especially Plectambonites sericeus and Dalmanella testudinaria, are so plentiful that they occur in practically every outcrop and almost cover the surface of certain layers. The fauna is limited to the following, listed in order of abundance:

Plectambonites sericeus
Dalmanella testudinaria
Joints of crinoid stems (very small)

Genus **Dinorthis** Hall and Clark.
Dinorthis berkeyi, sp. nov.

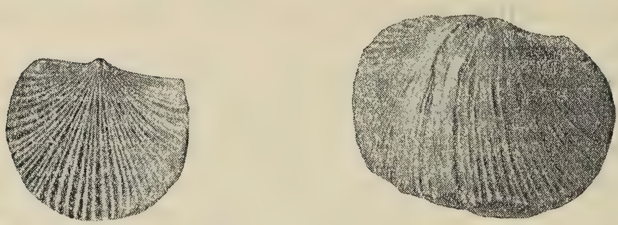
(Figure 6)

Description. Shell of medium size. Width 34 mm; height 26 mm; depth 12 mm.

Brachial valve is strongly and regularly convex, with greatest convexity in the central portion of the valve. The maximum width occurs about one-third the distance from the beak to the anterior margin. The surface is marked by 50 to 60 sharp radiating striae which increase first by bifurcation and later by intercalation: near the anterior margin there are three striae in 2 mm.

Pedicle valve is nearly flat. At the umbo it is marked by a small sharp elevation, and near the anterior margin by a broad indefinite sinus.

[95] Ruedemann, Rudolf. The Lower Siluric Shales of the Mohawk Valley. N. Y. State Mus. Bul. 162. 1912. Geology of Saratoga Springs and Vicinity. N. Y. State Mus. Bul. 169. 1914.



a b

Figure 6. Dinorthis berkeyi Holzwasser.
a Brachial valve. *b* Pedicle valve. Natural size.

Locality. Dinorthis berkeyi is common in certain calcareous sandy slaty shale zones in the Hudson River formation in the Newburgh quadrangle. The locality of the type form of the species is the south side of the state road three miles southeast of Clintondale and one mile by road west of the eastern margin of the map. Here it occurs in great numbers with equally numerous Dalmanella testudinaria, Plectambonites sericeus, and fragments of small crinoid stems. In lesser abundance in the same beds is found Rafinesquina deltoidea.

Preservation. The close and intense folding which these beds have undergone has resulted in considerable distortion of the fossils preserved in them. This is especially noticeable in the convex brachial valve of Dinorthis berkeyi, which is usually so distorted as to appear unsymmetrical and somewhat different in index from the less distorted nearly flat pedicle valve.

Affinity. Dinorthis berkeyi differs from D. subquadrata, which it otherwise closely resembles, in the more regularly oval outline of the shell.

Dinorthis berkeyi n. s.
Dinorthis pectinella
Rafinesquina alternata
Rafinesquina deltoidea
Lepidocoleus jamesi
Worm borings
Dicranograptus nicholsoni Hopkinson
Platystrophia sp. indet.
Parastrophia hemiplicata
Ctenodonta sp. indet.
Orthoceras sp. indet. (2 species)
Batostoma sp. indet.
Tretaspis, probably T. reticulata Ruedemann.

Several fragments of Bryozoa were also found, but they were weathered so badly that not even the genus could be determined. In a quarry on the state road immediately east of East Coldenham, the bedding surfaces of the slate were almost covered by indefinite markings, that looked like indistinct graptolites. It is probable that Corynoides calicularis and small Ostracods are

represented in the shiny carbonaceous films, but no determination is possible. On the west bank of the Wallkill river at Walden an exceptionally fossiliferous bed of calcareous sandstone (plates 26 and 27) contains many fragments of an orthid shell, so weathered and broken that it could not be identified. Ries[96] called it Dinorthis pectinella, which it may be, but it also resembles Plectorthis plicatella.

Not one of these fossils is limited enough in vertical range to allow of a very definite correlation. All that can be said is that the association of fossils indicates the Trenton age of the Hudson River formation in the Newburgh quadrangle. Its stratigraphic position however, above limestone probably basal Trenton in age, shows that it is not very early Trenton. Its similarity both lithologically and faunally with the Snake Hill formation, which farther north in the Hudson valley overlies the Normanskill and underlies the Schenectady formations, points to a horizon older than the late Trenton or Utica. Its age, therefore, is thought to be middle Trenton, and equivalent to the Trenton limestone at Trenton Falls, N. Y.

The conclusion reached from both field observations and consideration of the lithology and fauna of these slates and graywackes is that they represent one horizon only and are to be correlated with the Snake Hill formation of the northern Hudson river region, and with some part of the Canajoharie and lower Schenectady formations of the Mohawk valley. This conclusion, however, does not agree well with the finding of graptolites of Normanskill age at several localities in the adjoining Poughkeepsie quadrangle. Nearest the Newburgh area itself are the occurrences of Normanskill species in the slates 2 miles south and 1 mile north of Highland[97] There the strike of the beds is such as to bring them directly into the Newburgh area, but so far they have never been noted. Two explanations of these conditions are possible: either the Normanskill shale is only apparently absent, or it is really missing. In the first case, it may have escaped differentiation in the great mass of slaty rocks, since there is no outstanding contrast in appearance between the Normanskill and Snake Hill formations. Fossils are usually scarce and hard to find in both, and the thick cover of drift may conceal the Normanskill completely. In the second case, it may be absent due to folding, faulting or representation by a different lithologic facies. A very

[96] Ries, H. N. Y. State Mus. Rep't 49, 2. 1895. p. 441.

[97] Booth, H. & Lown, C. Discovery of Utica Slate Graptolites on the West Side of the Hudson. Amer. Jour. Sci., ser. 3, 26: 380–81.

special set of conditions of erosion of the northward pitching folds may prevent the outcropping of the Normanskill, even if it is present beneath the surface; or a fault, masked in the strikingly incompetent slates may have cut out this horizon to the south; or the horizon marked by slates to the north may be represented to the south by a different rock species. Slightly varying conditions in depth or distance from land might result in the deposition of lime mud at one place in the geosyncline, and at another not far away in the deposition of graptolite mud or of sandy mud with brachiopods.

If the conclusion is correct that the slates east of the belt of limestone north of Balmville are Snake Hill in age, as is suggested by the occurrence of the commoner species of the brachiopod fauna of the Snake Hill in the slate west of the little pond a half mile south of Balmville, and by the general aspect of the slate, then there seems to be no place for the Normanskill slate, unless it is masked in the undifferentiated Snake Hill formation. It is possible also that the Normanskill exists as an interbedded slate in the limestone, though this is not considered as probable as the hypothesis that the Normanskill is present as a facies of the lower Snake Hill recognized by its Graptolite fauna, which is of limited extent, and that it may be present, though not recognized. If this is the case, further observations and the opening up of new cuts will bring it to light. Since, however, the contact between the slates and the limestone is here thought to be a fault contact, the Normanskill horizon may have been cut out by the faulting.

Thickness of the Hudson River beds. The thickness of the Hudson River beds can probably never be accurately ascertained, "in consequence," says Mather, "of the rocks having been deranged, upheaved and tilted in almost every direction where they are visible."[98] The difficulty is increased by the following facts. The boundaries can practically never be determined on account of the covering of rock debris from the harder and more massive formations which lie stratigraphically above and below it, and on account of the thick drift cover. Secondary structures, principally cleavage, often so confuse the bedding that the attitude of the strata can not be determined. The beds dipping on the whole steeply and uniformly in close isoclinal folds are so similar and vary so markedly within short distances that repetition by folding is recognized in no specific case.

[98] Mather, W. W. Natural History of New York Geology, pt I. 1843. p. 369.

Plate 26

Plate 27

Pieces of the very fossiliferous phase of the Hudson River formation. A thin bed of calcareous sandstone, which outcrops on the west side of the Wallkill river at Walden, is made up largely of brachiopod shells.

The slate belt in the district is in many places fully 16 miles wide. If the dip of the beds were constant throughout this breadth, the slates would need to be several miles thick. Folds, however, are known to exist. A large anticline has its crest parallel to the Wallkill river at Walden, where the west dip breaks the montony of the general easterly inclination. From the plotting of dips and strikes over the area, many pitching folds are indicated. Ries found numerous and gentle flexures in the slate belt of Orange county.[99] Details of structure, minor small folds and faults (plate 28) which have been observed are also taken as evidence of similar major structures. The same association of fossils occurs throughout the belt; none of the common forms drop out and no new ones are added. It seems more likely that the one fossiliferous horizon is repeated many times by folding and faulting than that the same sparse fauna continues without modification through a great vertical range. Further, in neighboring regions, and especially to the south where there has been the same general development and where many horizons are readily distinguishable, the structure is obviously that of repetition by folding and to a lesser extent by faulting. It thus seems probable in the highest degree that a very great thickness of the slates does not exist in the district in question. On the other hand, very special conditions of folding and erosion would be necessary in order to get a breadth of 16 miles floored by a single thin formation.

Since any actual measurement is impossible, other methods for reaching some judgment of the thickness must be employed.

The Snake Hill formation is equivalent to the Trenton limestone, or some portion of it. In the opinion of the writer it represents about the same time as does the Trenton at Trenton Falls. There the 450 feet of limestone is Middle Trenton, the base and upper beds of that formation not being exposed. The limestone was deposited further out from shore, in the zone to which terrigenous material did not reach. Since nearer shore the land waste was heaped up, deposition occurring at a rate probably several times that in the undisturbed waters to the west, the equivalent of 450 feet of the organically deposited limestone may be some 1500 or 2000 feet of current deposited rock waste. A similar thickness has been computed by Ries for the shales in Orange county[100] and by Berkey[101] for the same formation on both sides of the Hudson river north of the Highlands.

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[99] Ries, H. *Loc. cit.* p. 440.
[100] Ries, Heinrich. N. Y. State Mus. Rep't 49, 2. 1895. p. 401.
[101] Berkey, C. P. N. Y. State Mus. Bul. 146. p. 56.

The Shawangunk Conglomerate

The "white rocks"[102] of the Shawangunk mountains overlie geologically all the other bedrock of the district, and rest upon the above-described slates and shales generally with a marked unconformity. A period of nondeposition and of diastrophism apparently separated these two, for whereas in the front range of the Shawangunk, known in this region, as Milbrook mountain, the conglomerate dips gently to the west, the underlying shales are standing at a high angle toward the east or toward the west.

The Shawangunk formation is a conglomeratic quartzite and conglomerate so massive and resistant that it stands out on the landscape as conspicuous ledges and vertical cliffs (plate 29) at the base of which lie great heaps of the large white rectangular blocks. The lowest beds exposed in the Shawangunk mountains are coarse and poorly sorted. The pebbles are prevailingly quartz, and average less than ½ inch in diameter, except in the basal beds where they are 3 to 4 inches across. The beds vary in thickness from several inches to several feet, and they are generally white with a yellow or greenish tinge, though toward the top some of the conglomerate is reddish. The pebbles are prevailingly vein quartz and are subrounded. Occasionally between conglomerate or sandstone beds occur thin layers of shaly sandstone or of red or green shale.

Under the microscope the rock is seen to be made up almost entirely of quartz grains. Plate 30 is a photomicrograph of a thin section of white quartzite, showing the generally simple, clear quartz grains, with the innumerable inclusions of bubbles and magnetite dust. A few composite quartz grains and tourmaline complete the coarser content, which is well bound together in a cement composed of quartz, sericite and a black metallic substance, probably magnetite. Reorganization of the original clay binder has caused interlocking of the grains so that the rock is very strong. Some of the quartz grains show further secondary enlargement. A coarser facies of the Shawangunk, a white conglomerate, is represented by plates 31 and 32, which are photomicrographs of two fields in the same slide. The first differs only from the preceding figure in size of grain, being about three times as coarse. The second exhibits part of a composite quartz pebble, and the original interlocking habit of the old crystalline rocks from which it was derived. Many of the grains extinguish irregularly as a result of strain, and granulation of the

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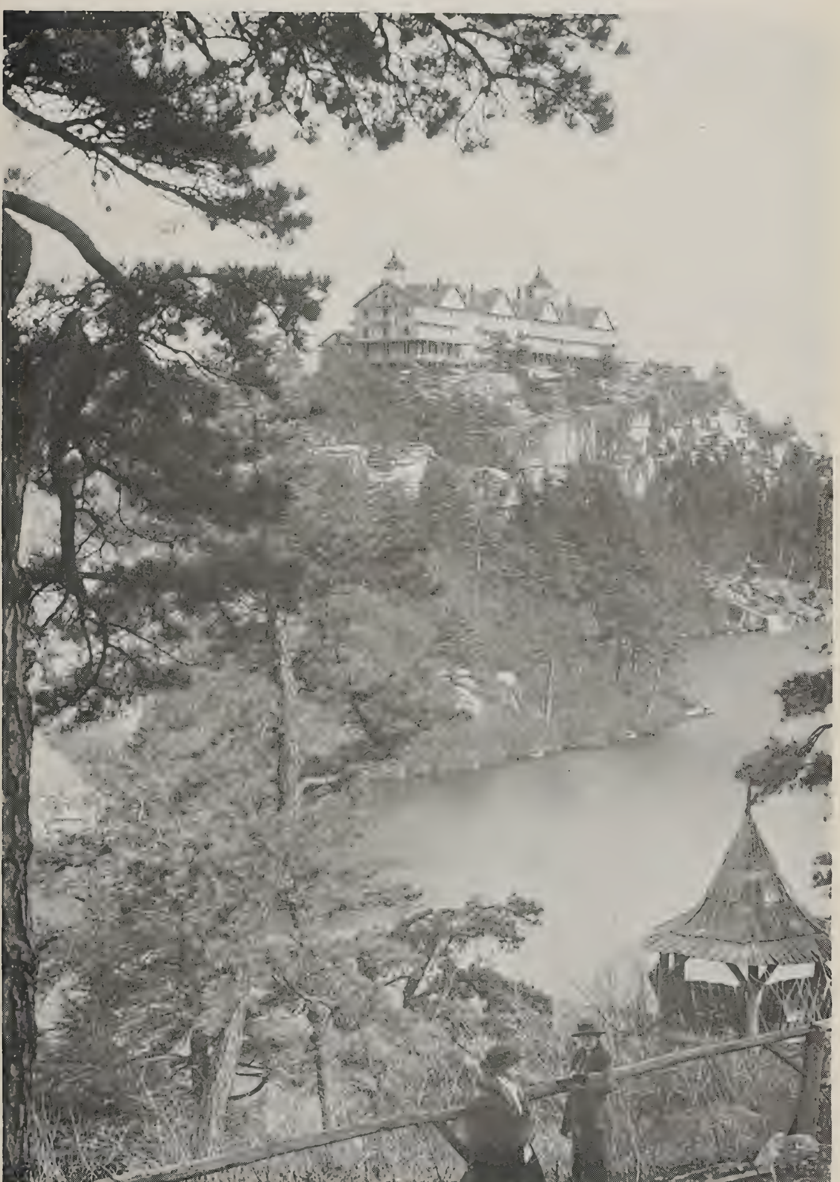
[102] Mather, W. W. Geology of New York, First Dist. 1843. p. 353–55. White rocks is " Shongum " of the Indians.

Plate 28

Small thrust fault in the Hudson River slates 2 miles south of Libertyville.

Plate 29



The eastern shore of Lake Minnewaska. The cliff on which stands Cliff House rises perpendicularly 150 feet from the lake.

quartz shows in the small pepper and salt patches. These are probably the result of stresses set up by Appalachian folding. Magnetite, zircon and apatite also occur in the rock, but included in the quartz and in the interstices between the larger grains. The pebbles in the coarser conglomerates are practically always quartz, and are well worn. These are bound together by a cement that is very largely siliceous, making a compact impervious rock.

At Minnewaska[103] the thickness is estimated to be close to 500 feet, and both highest and lowest exposed members are conglomeratic with an alternation of sandstones and conglomerate in between. Nowhere in the Shawangunk range has a complete section been measured; in general, however, the section is composed of a lower division about 100 feet thick, resting unconformably on the Ordovician Hudson River series, and separated from the upper part by a red shale, 50 feet thick, and of an upper division, 400 feet thick, upon the eroded surface of which to the west lie calcareous shales. Both divisions are largely conglomeratic, with beds differing mainly in coarseness. The upper division is especially diverse in character, consisting of many alternations from white conglomerate to white sandstone.

The following is a detailed section, which was measured at Peterskill falls by Billingsley, and which although incomplete may serve as a type for the general district of the Shawangunk mountains in the quadrangle.

	Feet
Coarse white conglomerate	10
Sandstone and conglomerate becoming finer toward the base	50
Cross-bedded shaly sandstone	2
White sandstone and conglomerate	12
Cross-bedded yellow sandstone and conglomerate with green shale partings	10
White sandstone	1
Red conglomerate	3
Fissile green shale	3
Massive red sandstone	2
Orange and red shale (slaty)	5
Impure sandstone	2
Green shale	10
Thin bedded white sandstone and sandstone and conglomerate becoming coarser toward base	50
Coarse conglomerate	10
Concealed by drift — about	75
Unconformity (contact not seen) total	245
Hudson River shale	

[103] Billingsley, Paul. Unpublished M. A. Thesis, Columbia University, 1910, on The Shawangunk Grit, Its Structure, Origin, and Stratigraphic Significance.

The Shawangunk overlies the Hudson River formation, and although no contact between them was observed in the quadrangle, they are probably unconformable. In the Trapps where at several places only a short covered area separates the two formations, their dips were very different, the conglomerate dipping very gently west, the shale dipping steeply east or west. Near the contact with the conglomerate, the shales are especially slaty and seem to be much crushed and sheared.

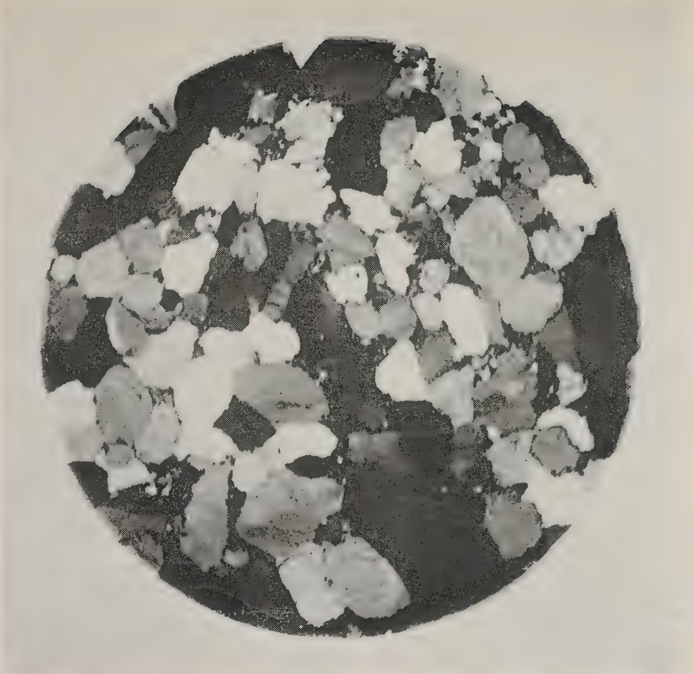
Several broad, gentle folds are visible in the Shawangunk; the Coxingkill, Peterskill and Sanderskill are flowing in very shallow synclines. Lake Minnewaska is on the crest of an anticline, which just north of the lake, between Beacon hill and Dickie Barre, has been breached exposing the underlying Hudson River formation.

The smaller features in the topography of the Shawangunk mountains are influenced by the joints developed in two prominent systems, one along the strike, north 20° east, the other transverse to the strike, north 60° west. These intersecting joint planes have outlined large rectangular blocks, which have been separated by settling due to weathering and to the undermining of the Hudson River rocks beneath. This has resulted in the formation of fairly deep vertical clefts, several of which may be connected and be continuous for 500 feet or more. One of these irregular passages occurs about a mile east of Lake Minnewaska, a short distance down the slope of Beacon hill, and is known as "The Crevices." These are composed of many irregular passages, generally not more than 5 feet wide and varying in depth down to 150 feet below the surface. The floors of the deeper portions are often wet where springs seep through the cracks. Fine opportunity for observation of the character of the rock is given by the clean vertical walls in the broad joints. Massive beds, several feet in thickness, are interbedded with layers not 6 inches thick, all of which show torrential cross-bedding, tiny lenses of fine conglomerate and sandstone quickly petering out. There is no regular increase in coarseness toward the top or the bottom of the 150 feet exposed in the crevices, but an irregular repetition of coarse and of fine grain.

Both origin and age of the Shawangunk conglomerate have occasioned much discussion and difference of opinion. Until recently it was considered equivalent in age to the Medina sandstone (early Silurian) of western New York.[104] Then fossils were found in the red High Falls shale which overlies the Shawangunk conglomer-

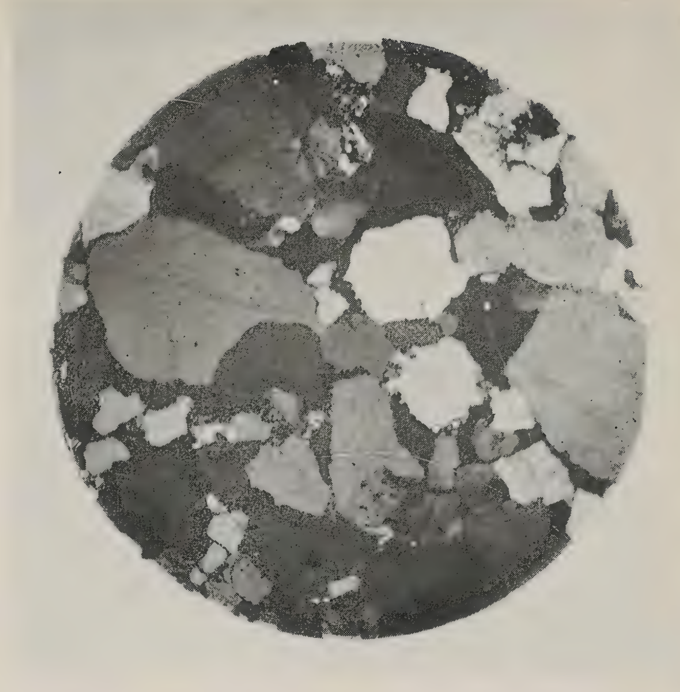
[104] Schuchert, Charles. Silurian Formations of Southeastern New York, New Jersey and Pennsylvania. Bul. Geol. Soc. Amer., v. 27. 1916. p. 531–54.

Plate 30



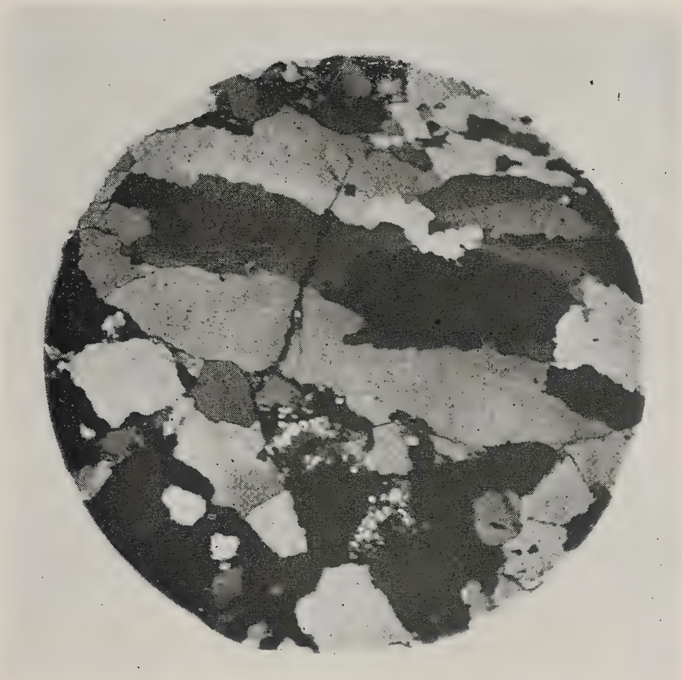
Photomicrograph of the Shawangunk quartzite, from an outcrop along the Coxingkill, about a mile south of the map limits. No. 15–40. Taken in polarized light, magnification 25 diameters. All the larger grains are quartz and show a finely interlocking habit. The finer interstitial material is in small amount, and consists of quartz, sericite and a black metallic. Strain shadows and lines of inclusions are visible in most of the grains.

Plate 31



Photomicrograph of the Shawangunk conglomerate from the first cliff on the road from the Wallkill valley up the mountain. No. 18–41. Taken in polarized light, magnification 25 diameters. In greatest amount are the simple quartz grains with slightly interlocking margins, due to reorganization of the clay binder. This rock is much coarser than that represented in plate 30. The quartz grains are crossed by many intersecting lines of bubbles. Crushing of the rock is shown in the granulated areas (pepper and salt patches).

Plate 32



Photomicrograph of the Shawangunk conglomerate. A different field from the same slide as plate 31. No. 16–41. Taken with crossed nicols, magnification 25 diameters. This field exhibits features similar to those in plate 31, and in addition the large composite quartz grain that indicates derivation from an old crystalline rock.

ate, and which was proved by the fossils to be of Salina age.[105] Since the red shale was believed to follow the conglomerate without any break in deposition the latter was considered Salinan also. The discovery by Clarke and Ruedemann of eurypterids similar to those of the Pittsford shale (basal Salina) in the Shawangunk further strengthened this correlation. In 1910, however, Van Ingen presented a paper before the Geological Society of America, in which he stated his conviction that the Shawangunk formation is equivalent in age to the Medina, Clinton and Niagara and is therefore older than the Salina.[106] The conclusion he based on the following facts: first, that the eurypterid faunas of the Shawangunk and Pittsford formations are not identical in species and varieties; second, that the range of the eurypterids, which was formerly thought to have its lower limit in the horizon of the Salina, had been extended by Ruedemann's find of eurypterids in the Schenectady shales at Schenectady, N. Y., into the Ordovician; third, that eurypterids found by him in the Shawangunk grit at Delaware Water Gap were pronounced by Ruedemann to be identical with those found in the grit at Otisville; fourth that at Swatara Gap, Pa., he found Tuscarora quartzite overlain by a series of clastic siliceous sediments, which in the lower part contained representatives of the Clinton and the Niagara marine faunas associated with shales in which were eurypterids identical in species and varieties with those found in the Shawangunk at Otisville and Swatara Gap; fifth, that Arthrophycus alleghaniensis (commonly referred to as A. harlani), the index fossil for Medina time, occurs in the grit at High Falls, Rosendale, Delaware Water Gap, and Swatara Water Gap. The last-mentioned proof heretofore has been much discounted, owing to the indefinite idea we have had as to the nature of the "jointed plant tracks," and to the difficulty of identifying the more indefinite burrows. Schuchert,[107] however, believes them to be the burrows of "an errant annelid, Arthrophycus alleghaniensis, similar to the lob-worms of the English sand beaches," and considers them reliable horizon markers. According to Schuchert, they have never been found except in the Medina and in the Shawangunk formations.

These facts seem to establish the age of the Shawangunk as equivalent to the Medina and part of the Clinton-Niagara. Grabau,[108]

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[105] Schuchert. *Loc. cit.* p. 533.
[106] Van Ingen, Gilbert. Science, June 9, 1911. p. 905.
[107] Schuchert, Charles. *Loc. cit.* p. 535.
[108] Grabau, A E. Bul. Geol. Soc. Amer., v. 24. 1913. p. 480.

however, and other stratigraphers hold that it belongs higher in the geologic column and in part at least to the Salina, because they believe it to be continuous in deposition with the overlying red beds which are Salina, and between which and the Shawangunk no break is visible. Although a physical break has not been observed between these two formations (due in part no doubt to the fact that the contact is usually covered), Schuchert[109] considers conclusive the evidence of the break, which he traces west and south.

A very interesting suggestion in the correlation is introduced by Van Ingen and Schuchert who see, in the pink and red conglomerates that predominate in the upper portion of the Shawangunk, the end phase, one might say, of the Clinton iron ore.

Several theories of origin have been suggested for the thick, coarse, almost pure quartz, sediments known as the Shawangunk. Schuchert[110] finds in it many evidences of shallow-water deposit near the shore; Van Ingen believes it represents a delta or littoral facies; Clarke and Ruedemann consider that "the Shawangunk grit represents a tidal zone deposit of an encroaching sea or of a delta."[111] In Grabau's opinion the Shawangunk was laid down as a subaerial delta fan upon land.[112] At least all agree that the basement upon which the material was piled up was near sea level. Very probably at times the streams heaped up debris so swiftly that the surface rose above sea level, only to be covered again by the shallow sea. One point upon which there is relative agreement is the source of material. Schuchert[113] says: These sands and conglomerates came from Appalachia to the east of the present Atlantic shorelines, then a high land of crystalline rocks elevated in late Ordovician time during the Taconic disturbance. The rivers were long and had reduced the quartz to fine sand and fairly well-rounded, small pebbles, and the work of the sea waves had washed into deep water the muds of which so little comparatively is present in the Shawangunk and Tuscarora formations.

This appears to be a very reasonable conception of the conditions under which the sediments accumulated. In this way only can be explained the great thickness of semirounded quartz grains and pebbles, with here and there thin seams and lenses of mud, the presence of regular bedding, of torrential cross-bedding, and of marine and possibly of fresh water forms.

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109 Schuchert, Charles. *Loc. cit.* p. 537–38.
110 Schuchert, Charles. *Loc. cit.* p. 535.
111 Clarke, J. M. & Ruedemann. N. Y. State Mus., Memoir 14. 1912. p. 105.
112 Grabau, A. W. Bul. Geol. Soc. Amer., v. 24. p. 526–28.
113 Schuchert, Charles. *Loc. cit.* p. 535.

Plate 33

Small hill of unstratified drift on the golf links ½ mile southeast of Balmville.

Plate 34

A gravel pit in the semistratified drift east of the Balmville tree.

Plate 35

A field south of Balmville fairly covered with boulders of sandstone.

Plate 36

Large sandstone boulder dropped by the ice on the Precambrian on the southern flank of Cronomer hill.

GLACIAL GEOLOGY

A map recording evidences of glacial activity in the Newburgh quadrangle would not leave a square mile of the area unmarked, and would show prominent effects of both erosion and deposition by the Pleistocene ice-sheet.

Deposition by the Ice Sheet

Apparently deposition by the ice has been by far the more effective in the districts. No considerable area was observed where the surface was free of glacial drift. The latter is largely in the form of ground moraine, the unsorted, light-colored, sandy, and bouldery drift that forms a mantle of varying thickness over most of the region. On the higher elevations, such as the Shawangunk mountains, King's hill, Cronomer hill and the Marlboro mountains, the drift cover is irregular, much bare, smoothed and striated bedrock being visible. Thicker drift lies in the valleys, especially in the lowland near the Wallkill river, where the bedrock is buried to a considerable depth, so that over large areas the underlying formations are entirely concealed. This veneer of unconsolidated glacial debris, seldom more than 100 feet and on the average about 20 feet thick, has evened the more rugged topography of the preglacial surface and has superposed upon it the undulating smoothness of the ground moraine. Many of the small hills are composed of this till, which is exposed when the hills are crossed by roads (plate 33) or cut into for road material. Forty feet of unstratified drift is exposed in the hill at the east side of the state road in Balmville. The thicker drift mantle in the valleys, particularly the lower ones developed on the Hudson River rocks, has been accumulated in part by the activity of glacial streams. This is the modified drift, which is recognized by the greater sorting of the material, somewhat irregular layers of fine sand, of gravel, and of mixed sand and gravel, and lenses of coarse materials, with boulders 6 inches long, being repeated frequently. Such accumulations often furnish gravel for road making. A cut for that purpose was opened about a block east of the Balmville tree, which stands at the end of the trolley line between Newburgh and Balmville. A small section of this cut (plate 34) shows the rude stratification of the glacio-fluvial material, accumulated possibly in the form of a sand and gravel delta by streams issuing from the ice. A thicker accumulation of similar kind is exposed in the little hill ½ mile west of Clintondale station, on the

Central New England Railroad. The entire west side of the hill is being cut away, showing fine cross-bedding in the sand, and beds of moderate sized boulders.

Exploratory borings by the board of water supply of New York City[114] furnished much data about the drift. Figure 3 shows the types and thickness of drift filling the valley of the preglacial Wallkill river, which is seen to have been cut much below the level of the present channel of the river. Of this glacial filling Berkey says:

A considerable proportion of the drift mantle especially in the central and deeper portion of the valley, is modified assorted sands, gravels and silts or muds. In part they represent deposits in standing water laid down at a time when the lower (north) end of the valley was obstructed by ice and while waste was poured into the valley from neighboring ice fields. It is impossible to reconstruct the beds of these materials with any degree of accuracy. But it is at least certain that lens or wedgelike layers of different quality of material were penetrated, indicating oscillation and overlapping of deposition conditions, boulder beds and till being interlocked with assorted sands and gravels. But there is apparently no evidence of ice deposits of greatly differing age.[115]

The cross section along the Wallkill siphon (figure 7 in pocket) also shows the varying but omnipresent drift cover.

Large erratics are irregularly distributed but are especially common in a belt extending from the Marlboro mountains southward over Cronomer hill and through the city of Newburgh. The boulders are generally of sandstone and have been smoothed and striated by the ice. In certain spots, especially west of Newburgh, cultivation of the land is impossible on account of the great numbers of boulders (plate 35). Silurian and Devonian limestones and sandstones from the region to the west, Precambrian crystallines from the Adirondacks, and the rocks from the immediate vicinity are also recognized among the larger boulders. On the Precambrian basement of the southern slope of Cronomer hill stands a great boulder of graywacke (plate 36), and an immense angular block of Wappinger limestone (plate 37) rests on bouldery drift covering Hudson River slates a short distance north of Leights pond. Up in the Shawangunk mountains most of the erratics are of the conglomerate that forms the hard capping there, and they continue to be numerous east in the valley at the base of the mountains, but with distance from the higher land gradually give place to masses of sandstone.

A little more than a mile southeast of Wallkill is a narrow de-

114 Berkey, C. P. N. Y. State Mus. Bul. 146. 1911. Plate 26, between p. 150 and 151.

115 Berkey C. P. *Loc. cit.* p. 157.

Plate 37

Immense angular block of Wappinger limestone resting on other glacial erratics and drift which covers the Hudson River slate north of Leight's pond.

Plate 38

Glaciated surface of the Hudson River slates south of Plattekill. The hammer lies with its handle parallel to the glacial striae which trend north 20 degrees west.

pression (marked on the map by a depression contour), slightly over ½ mile long, in which are several small, rolling hills, all a little lower than the surrounding country. A cut has been made in one of the hills and exposes 20 feet of semistratified drift, containing fine cross-bedded sand and coarser mixed lenses with boulders up to 6 inches in diameter. The depression is glacial, probably a kettle or a nest of kettle holes. Many other depressions in the district have a similar origin, and some of these hold small lakes, as does that east of Modena, although this lake is not shown on the map.

From Roseton south along the Hudson a gently sloping terrace is developed on clay and sand and to a slight degree on glacial drift. The terrace varies both in width and in height. Ries[116] says: "The terrace at Newburgh extends up to 210 feet." This statement is true, however, only in the southern half of the city of Newburgh; the northern portion, that included on the Newburgh sheet, is built almost entirely on solid rock. Throughout the city are outcrops of the bedrock, as well as all along the West Shore tracks north of the city proper. The foreman of the construction company that laid the tracks on Broadway some 15 years ago said that the drift cover was not thicker than 10 feet, and that under that came "massive slate rock" which had to be blasted. He also mentioned the difficulty experienced in drilling into some exceptionally large boulders. The thin marginal portion of the Moodna delta may have extended northward and covered all Newburgh, especially the lower part near the river, but all trace of this has been obliterated now by the work of man—the building of docks and warehouses along the river, the streets and houses back from the river, and the filling-in necessary to increase the area of land along the river front.

Dating from the Pleistocene also are the clays so largely developed along the Hudson river in the latitude of the sheet. The large deposits, however, lie just to the north or south of the limits of the quadrangle. Along the Wallkill river at New Paltz pits have been opened up over a considerable area underlain by the clays. The latter indicate a period of depression, during the recession of the ice, when the larger valleys became estuaries, in whose quiet waters there slowly settled the extremely fine rock flour brought down by milky glacial streams. The clay which is finely laminated is chiefly bluish gray, due to the ferrous condition of the iron, except in the upper few feet where weathering has changed it into the yellow ferric limonite. At New Paltz red clay also occurs and is worked.

[116] Ries, Heinrich. Geology of Orange County, N. Y. State Mus. Bul. 49, Ann. Rep't, v. 2. 1895. p. 464.

In this case the color is due to iron present in the form of hematite.[117]

According to Berkey[118] and de Geer[119] seasonal changes are shown by the differences in material in the tiny laminae; dark, fat clay that looks heavy and shiny is the very slowly accumulated deposit of the autumn when no melting is going on; the gap in sedimentation marking the winter season is broken by the freshets after the first thaw, when coarser silt is laid down. Each storm leaves its mark and the year's high point is reached in summer when relatively thick laminae of sands, about ½ inch in thickness, accumulate. The yearly bands, called varves by de Geer, include laminae representing deposition during each season except winter, which is marked by a gap; a thick varve indicates a warm year, a thin varve a cold year. By careful examination of clay deposits which are thus laminated, and by the correlation of clays in both Europe and America de Geer has attempted to calculate the length of late glacial and post-glacial time.[120] In the clay at New Platz this seasonal variation is very evident in the fine, horizontal bedding which causes the clay to separate readily into layers 4 to 8 inches thick and greatly facilitates the digging. On account of continued slumping, however, only a few feet of the bedded clays could be measured and therefore could not be satisfactorily fitted into the schedule of glacial time. A few feet of sand covering the clay mark the more rapid melting of the ice.

Erosion by the Continental Ice Sheet

Much less effective on the topography of the greater part of the region are the results of glacial erosion. Although there are many evidences that the glacier cut into the bedrock and scraped off most of the residual soil, it covered so much of the surface again, in most places with a much thicker mantle than the preglacial one, that the proofs of erosion by the ice are largely hidden, except in the higher areas where many smoothed and scratched bare rock surfaces are visible and show marks of a glacial chisel. No effects of glacial cutting are visible in the deeply drift-covered Wallkill valley, although it is probable that the ice, its direction of movement influenced by the long depression, advanced approximately parallel to the lowland and carved in it deeper and wider valleys. Orange lake occupies a preglacial valley modified by the ice and blocked at the southern end by

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[117] Ries, Heinrich. Clays of New York. N. Y. State Mus. Bul. 35. 1900. p. 516.

[118] Berkey, C. P. Laminated Interglacial Clays of Grantsburg, Wis. Jour. of Geol. v. 13, no. 1, Jan.–Feb. 1905. p. 35–44.

[119] de Geer, G. Geochronology of the Last 12000 years. Comptes rendu de Congr. Géolog. à Stockholm. 1910 and 1912.

[120] de Geer, G. *Loc. cit.*

a moraine dropped by the retreating glacier. The lake was formerly of much greater extent, as the marshes indicate. On top of the hill about ½ mile south of Plattekill are many rounded exposures of the Hudson River beds, with surfaces marked by many long parallel striae trending north 20° west (plate 38). West of East Coldenham on the state road long parallel striae point north 15° east. Up over Cronomer hill the ice plowed its way; the crystalline outcrops on top are surprisingly low and inconspicuous in contrast to the prominent large sandstone erratics dropped by the ice. The small valley cut into the northeastern quarter of Cronomer hill looks like a glacial trough, the west side being steep, about 75° and beautifully smooth; the east side is smooth also, but very much gentler in slope. The drift in the trough is thicker than on the surrounding portions of the hill and is crowded with sandstone boulders.

Some of the higher hills in the midst of the valley have a peculiarly elongated oval shape. Between Orange lake and New Hurley is a group of these hills, in which Raccoon hill and Kings hill, the higher ones respectively northeast and southeast of St Elmo, stand out as especially drumlinoid in form. They are rock hills, however, and rise somewhat higher above the surrounding country than do the usual drumlins. Drift is thin on the tops of the hills, which despite the very slaty character of the rocks still show by the rounded surface contours the cutting done by the ice, but on the lower slopes thick drift is plastered on to the rock core. These elongated hills are generally steepest on the northwestern side. Deposition and erosion by the ice are probably equally responsible for these elongated rock hills.

The most striking evidences of glacial erosion are found up in the Shawangunk mountains. Practically free from the ground moraine that buries the valley areas, this higher land has every rock surface smoothed and polished by the ice, and perched here and there huge angular blocks of the Shawangunk grit plucked from nearby ledges. Often the surface of the massive white rock is fluted by numerous long parallel grooves, less than an inch deep and several inches wide, that cover the rock, and on the polished surfaces glacial striae show the general direction of ice movement to have been from about north 20° east. These are still evident despite the fact that the polished smoothness of these glaciated surfaces has been largely destroyed by subsequent weathering, which has freed the pebbles in the rock and developed many tiny basins. Nevertheless the great proportion of the rocks are smooth enough to make walking, except on nearly level outcrops, a rather difficult process.

By far the most beautiful part of the area covered by the New-

burgh quadrangle is that high up on the crest of the Shawangunk mountains around Lake Minnewaska. There the erosive activity of ice is largely responsible for the natural features. Lake Minnewaska, an exquisite little lake, almost ½ mile long and ⅕ of a mile wide, lies on the crest of the mountain 1650 feet above sea level. It is a rock-bound lake, cut probably entirely in the Shawangunk grit, which rises 60 to 150 feet in perpendicular cliffs and in overhanging ledges directly from the water's edge. The rock wall is highest on the east side of the lake (plate 39) where more than 150 feet above the surface of the lake stands the Cliff House. The lake's rim preserves a considerable elevation on all sides except at the southeastern end where the outlet, a headwater branch of Coxingkill flows out to the southeast and then to the east into the main stream. The hard, resistant rock in which the basin is cut is weak in one respect—it is deeply jointed in two intersecting systems, one striking north 20° east, the other north 60° west. These lines of weakness furnish the most favorable conditions for ice-plucking and cutting. Perhaps a preglacial stream had its course along the line of the present lake, and the ice moving through it scoured it more broadly, at the same time freezing to and carrying forward the blocks of conglomerate separated from the parent ledge by planes of jointing and bedding. During a period of relative stability of the ice front, a small terminal moraine was dropped across the lower and southern end of the valley, closing it. As soon as the ice retreated to the north of the region, water from its melting filled the basin, and began to seep out through the pervious bar at the lower end. The lake is fed by springs, which are very numerous in the much jointed conglomerate.

To the southwest of Lake Minnewaska extends the beautiful valley of the Palmaghatt; its steep valley walls, cut in massive Shawangunk grit, are smoothed and striated The floor is covered with the large, angular blocks of conglomerate and with exceptionally beautiful tall hemlocks and mountain pines.

The seven thousand acres around Lake Minnewaska owned by the Messrs Smiley constitute one of the most beautiful natural parks in the State. Kept in excellent condition and with the minimum of artificial improvements, the park preserves a most perfect specimen of nature's sculpturing. A few roads have been built, around the margin of the lake, down the Palmaghatt, along the east rim of the Palmaghatt to Millbrook mountain, and along Millbrook mountain to Lake Mohonk. These lie for the most part on the glaciated surfaces of the Shawangunk conglomerate, and from them in all directions extend magnificent distance views, to the Catskill mountains, to Lake Mohonk, to the Hudson river, and to the Highlands of the Hudson.

Plate 39

View of Lake Minnewaska, looking from the northern end southeast toward its outlet.

STRUCTURAL GEOLOGY

Introduction

Wherever the formations over large areas are so similar or so lacking in diagnostic criterions that they can be separated into units only with great difficulty, the solution of the structural conditions will be arduous and less certain than in a district in which the rocks are readily distinguishable, whether it be on lithologic or faunal dissimilarity. Thus comparatively complex structures in the Helderberg limestones of the Catskill region have been unraveled, whereas similar structural relations in the vicinity of Kingston are interpreted with much less assurance because of the difficulty in distinguishing between similar formations and because of the physical characters of the rocks.

The Newburgh quadrangle presents these indecisive elements in the extreme—formations that contain scanty fossil evidence as to age, and that are so alike lithologically over large areas that no subdivision of them is possible; structural relations that are largely masked, both by reason of the physical properties of the rocks involved, and of the usual thick surficial cover. For these reasons even the major structural features are baffling, and in some cases are recognized only by extending the structural lines from immediately adjacent territory. It is thus no doubt true that the structural geology of the Newburgh quadrangle will be understood only when supplemented by a detailed study of contiguous areas where diverse and competent rocks preserve less obscurely the results of the structural history. In spite of these obstacles, detailed observations within the area under study have led to the recognition of many interesting structures.

From previous observations the general structural history is more or less known, and is that shared by the northern half of the belt affected by the Appalachian folding, the region whose structures are referable to three major diastrophic movements, Taconic, Appalachian and Triassic.

The most typical structural form is the close isoclinal fold pitching about 15° to the north. The dip of the beds is not uniform; although most of the dips are steep and to the east, some west dips were noted and many east dips that are as low as 20°. This characteristic folding is a composite effect of compressive stresses accumulated during the late Ordovician and Permian periods. Although it is impossible to evaluate with any degree of accuracy the importance of these two times of disturbance on the present structures, it

seems probable that the typical small close isoclinal folds are dominantly the result of post-Shawangunk, Appalachian, rather than of pre-Shawangunk, Taconic movements, for the following reasons:

1 The folds have more nearly the trend of the Appalachian folding, northeast-southwest, than that of the Taconic folding, north-south.

2 Without a considerable overburden there could be no folding of this type, and there was little if any deposition upon the Hudson river until Shawangunk time.

3 The conditions in post-Shawangunk time were ideal for such a type of folding—a thick series of incompetent beds (the Hudson River terrane) between competent ones (the Wappinger limestone below and the Shawangunk conglomerate above).

4 Doubt is being cast upon the Taconic disturbance.[121] As far as the writer's observations in the Newburgh quadrangle bear on this question, the structural conditions can be explained without any deformational movement other than that at the end of the Paleozoic era. Although no contact between the Hudson River and Shawangunk formations was seen, observations were made on them where but a few feet of covered ground separates them. The dips of the two are in general entirely dissimilar, the gentle west dip of the Shawangunk contrasting with the variable dip of the Hudson River, which in places seems to have the same gentle west dip as the conglomerate a few yards away, but in a few feet has changed to a steep east or west dip. This diversity seems explicable, however, on the grounds of the different reaction to folding of competent beds, such as the Shawangunk, and incompetent beds, such as the Hudson River. Nevertheless, that there was a Taconic disturbance during which the rocks in southeastern New York were deformed is established beyond much doubt by observations made in neighboring areas. An exposure near Otisville shows a pronounced unconformity between the Hudson River and the Shawangunk formations[122] and a similar relation exists between the Hudson River beds and the Cobleskill limestone at Rondout.[123] Situated between these two

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[121] Clark, T. H. A Review of the Evidence for the Taconic Revolution. Proc. Boston Soc. Nat. History, v. 36, no. 3. 1921. p. 135–63.

[122] Clarke, J. M. The Eurypterus Shales of the Shawangunk Mountains in Eastern New York. N. Y. State Mus. Bul. 107. 1907. p. 298, pl. A.

Schuchert, C. Silurian Formations of Southeastern New York, New Jersey and Pennsylvania. Bul. Geol. Soc. Amer. v. 27, p. 544–45, pl. 21. 1916.

[123] Davis, W. M. The Nonconformity at Rondout, N. Y. Amer. Jour. Sci. ser. 3, 26: 392–93. 1883.

Van Ingen, Gilbert, & Clark, P. E. Disturbed Fossiliferous Rocks in the Vicinity of Rondout, N. Y. Rep't N. Y. State Pal. 1902. p. 1209–10.

Schuchert, C. *Loc. cit.* p. 540.

areas in which there is clear evidence of the Taconic disturbance, the rocks in the vicinity of Newburgh can be reasonably assumed to have suffered deformation at the same time. If the slates and graywackes of the Hudson River formation were at that time in the condition of the Cretaceous of the Atlantic seaboard today, the little lithified beds would have folded with only the load of the overlying layers of the same group.

Major Structural Features

The major structural features of the Newburgh quadrangle are those of the larger Appalachian valley province of which it is a part. The folding was intense; the close folds pitching to the north trend northeast-southwest; the dips are generally over 30°, and often the beds stand vertically or are overturned. Most of the folds are asymmetrical, the southeast limb having been pushed over on the northwestern limb, which thus becomes shorter and steeper, and may even move forward over the eastern one in a thrust fault. The larger folds are not simple, but consist of many minor folds, which become especially numerous when the rocks involved are the easily crumpled shales.

Structure of the Broad Belt of the Hudson River Formation

The characteristic structure of this broad belt is shown in the cross section of the Wallkill valley south of New Paltz (fig. 7 in pocket). This is drawn from the data recorded by the engineers of the Wallkill Siphon division of the Catskill aqueduct. In that section for 4½ miles the water flows through a tunnel, in the cutting of which Hudson River beds alone were encountered, and the dips and strikes carefully recorded. A study of the cross section leads to the following inferences:

1 The rock is very closely folded.
2 Most of the folds are of the type of isoclinal fold.
3 The dips are generally east (southeast) and are steep. Only two west dips are recorded. The east dips have a wide range, from 5° to 70°, the average being 41°.
4 The strikes vary also within wide limits, but the average is north 10° east.
5 Jointing and faulting on a small scale are not uncommon and give rise to lines of weakness in the rock.
6 Minor crumplings are frequent.
7 A drift cover of varying thickness entirely covers the surface.

This cross section can be taken as typical of the whole belt of Hudson River slates; the conclusions gained from the study of this limited stretch are those reached from the observations made throughout the low country underlain by the slates. The differences between it and any other cross section through the Hudson River rocks are believed to be unimportant, although for no other section is such detail procurable, because the rock shows from under the grass cover only where the drift is thin, and because even when the rock is visible, where cleavage and jointing are well developed, the bedding may not be determinable. The dips and strikes plotted on the geologic map indicates the same facts: the general trend of the folding is about north 15° east, and the average dip is 40° to the southeast. It is impossible to record on the map all the dips and strikes observed, because these change suddenly and frequently, indicating minor crumplings. Large folds are not visible and are difficult to decipher in the slates, which act as an incompetent member, crumpling and shearing between the much more competent beds above and below. The small, minor folds observed, however, are thought to reproduce on a small scale the pattern of the major folds.

A few small folds and faults have been observed. North of St Elmo a road crosses the railroad track, and cuts into bedrock, exposing a small syncline only a few feet across. Small anticlines and synclines are seen in an outcrop along the road entering Coldenham from the northwest. On the northwest-southeast road about a mile southwest of Forest Glen the low cliff on the north side of the road shows a small anticline and a small thrust fault (plate 28).

Figure 8

The plane of another fault is seen near the water's edge on the west side of the Wallkill river just north of the main bridge (the southern one). These are the only structures of the kind seen in the field. Other folds are indicated by the divergent dips and strikes of slightly separated outcrops. These were so numerous that all could not be plotted on the map. Another evidence of the folding is typically exhibited in the elongate hill west of the Dwaarkill. A road over the hill cuts through alternating graywackes and slates,

dipping 85° east. The direction of the cleavage in the slaty beds shows that these belong to the west limb of an overturned anticline,[124] and that they have been turned over beyond the vertical. The east

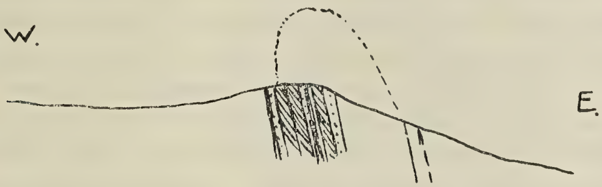

Figure 9

limb of the fold is nowhere exposed; it would probably show a similar dip, but the beds would not be overturned.

Physiographic evidence has been used in determining a large fault in the slates. For several miles north and south of St Elmo a prominent west-facing cliff extends at a considerable angle to the strike of the rocks. It seems probable that the scarp is the result of an oblique thrust fault of the Appalachian type. Another cliff which may have a similar origin is paralleled on the east by Black creek. There are in the district undoubtedly numerous faults, both large and small, and generally of the overthrust type resulting from the compressive stresses of the Appalachian revolution, but they are completely hidden in the drift-covered incompetent slates.

In the northwest and southeast portions of the region, where more competent formations constitute the bedrock, the larger structural features are more easily solvable, and give an idea of the not very different structures which doubtless continue into the incompetent slates but are concealed by them.

The Newburgh District

On the geologic map of the quadrangle the southeast corner is seen to consist of five structural units; two are essentially Precambrian inliers, Cronomer hill, and the northward extension of Snake hill from the Schunnemunk sheet to the south; two are limestone belts, which were originally one and continuous, but now seem to be separated at Balmville, one extending northeast and crossing the Hudson River, the other forming the bedrock of West Newburgh; and the fifth, the Hudson River formation, the matrix, as it were, for the others, and so similar to the broad belt of slates that no separate treatment is necessary at this point.

[124] Leith, C. K. Structural Geology. 1913. p. 16–21, 121.

The Cronomer hill inlier. Cronomer hill, the highest elevation in the southeastern part of the quadrangle, owes its topographic prominence to two factors: first, to the resistance of its bedrock, second to a movement that has thrust it up several hundred feet above the rocks that originally overlay it. On the geologic map Cronomer hill appears as an inlier, that is, "a mass of rock surrounded by beds which are geologically younger than itself."[125] Inliers are of several diverse types, and these in New York State have been critically studied by Doctor Ruedemann,[126] who distinguishes two major groups, the one produced by the agency of water, the deposition or erosion inliers, the other produced by diastrophism of the earth, the fold or fault inliers. As Doctor Ruedemann comments, however, inliers are seldom the result of one process alone, but generally of several agencies, one of which predominates.[127]

The Cronomer hill unit is distinctly of the type caused by diastrophism, and owes its elevation mainly to thrust faulting. Rudely trapezoidal in shape, it is separated from the younger formations which surround it by four oblique faults, two thrust and two gravity. On the west Precambrian rocks have been thrust over on Ordovician slates, the movement having been great enough to cut out the Poughquag quartzite, Wappinger limestone, and probably also part of the Hudson River slates. On the south another thrust fault has brought Wappinger limestone up against rocks of the Grenville, Poughquag, Wappinger and Hudson River formations. This fault seems to be the continuation of the one that constitutes the western boundary of the northern limestone unit. Corroborative evidence of its prolongation to the south of the crystalline mass was received from the record of a well that was recently drilled for water near the contact of the crystallines, slates and limestones. The well (on the north side of the road about one-quarter of a mile northwest of the "G" of "Glenwood Park") pierced 150 feet of limestone and went into slate. Along the contact of the two formations water was struck. These thrust faults are of the type generally connected with the folding of the Appalachian revolution, and probably are dipping at an angle of about 45° to the east and southeast respectively.

The fault limiting the inlier on the east is a diagonal gravity fault, along which from north to south the Hudson River slates, constituting the down dropped block, are brought into contact successively with

[125] Scott, W. B. An Introduction to Geology. 1909. p. 384.
[126] Ruedemann, Rudolf. Types of Inliers Observed in New York. N. Y. State Mus. Bul. 133. 1908. p. 164–93.
[127] Ruedemann, R. *Loc. cit.* p. 165.

Grenville, Poughquag and Wappinger. The clue to the structure here is found in the extremely discordant dips of the limestone to east and west of the road paralleling Gidneytown creek at the place where the creek makes the small abrupt bend to the east. At the eastern base of Cronomer hill, on the west side of Gidneytown creek, the Wappinger lies conformably on the Poughquag, and dips 20° east. On the east side of the creek the limestone is very shattered and is dipping 80° to the east. The much fractured, steeply inclined beds are thought to be the product of crush and drag near the steeply dipping fault plane. The structural relations at the northern side of the inlier are not evident. Hudson River slates, exhibiting erratic dips, are seen not far from outcrops of the massive crystallines. The contact between these is certainly a fault, which is believed to be a gravity fault similar to that along the eastern boundary. In both faults the slates have constituted the down dropped block. Such block faults are considered especially characteristic of the Triassic,[128] and they are therefore the product of a much later movement than are the thrust faults which they cut.

Figure 10

The diagonal trend of the faults which delineate the Cronomer hill inlier causes them to intersect one another and thus detach the inlier at least at the surface from the unit with which it was formerly continuous. In depth also this inlier is thought to wedge out, because of the intersection below the surface of the differently dipping planes of the thrust and gravity faults. Cronomer hill is thus thought to be detached as well at its base as at the surface from the old crystalline basement. It may be described then as a floating fault wedge, entirely sundered from the parent mass by an Appalachian thrust fault on the west and on the south, and by a Triassic gravity fault on the north and on the east.

128 Berkey, C. P. & Rice, M. Geology of the West Point Quadrangle. N. Y. State Mus. Bul. 225–26. 1921. p. 78, 115, 116.

The prolongation of the Snake hill inlier. Less complex are the structural relations of the smaller inlier that extends as a slender wedge into the city of Newburgh from south of the limits of the map. It differs from the Cronomer hill inlier in three minor respects: it wedges out to the north; it is geologically simple, consisting of rocks of Precambrian age only; it is topographically a depression. It is similar, however, in being bounded on the west by a thrust fault and on the east by a gravity fault. The dips of the planes of these faults have been determined in explorations in connection with the construction of the New York City (Catskill) aqueduct; the thrust plane dips about 45° to the east and the gravity fault plane much more steeply in the same direction. They will, therefore, intersect beneath the surface and quite sever the inlier from any attachment to the ancient floor. At the north the crystallines wedge out because of the convergence of the faults in that direction, and on the south a gravity fault is thought to cut diagonally across from northwest to southeast, dropping the north end of the wedge and perhaps offsetting it slightly to the west. The relations there are not clear, because deposits of the Moodna delta have deeply buried the country immediately north of Snake hill.

This inlier, however, is structurally similar to many of the inliers in the district and illustrates the combination of structures peculiar to them. It is limited on the west by a thrust fault of Appalachian type, on the east by a block fault of Triassic type, and these intersect one another not only at the surface, but also in depth so that the unit becomes a floating inlier or wedge inlier without roots. On the south it is cut by a gravity fault that has lowered it and offset it at the same time.

Figure 11

The Northeastern belt of Wappinger limestone. Although not an inlier within the limits of the district, this unit partakes largely of the major structures of the inliers discussed above. It is delimited on the west by a thrust fault, and on the east and south by gravity faults. To the northeast it is directly continuous with the limestone in the Poughkeepsie quadrangle, where the belt

is much wider, and is anticlinal in structure. South of Marlboro on its northwest margin, the limestone dips west, and to the southeast at Danskammer, it dips east.[129] In every outcrop of this unit

Figure 12

in the Newburgh quadrangle the dip is east, steeply (60°) along the river road, less steeply east of New Hope near the western limit of the limestone. This would indicate that the limestone ridge is a monocline faulted on both sides, but it does not preclude its being an anticline, because heavy drift prevents observations along the western margin. Very probably, however, the thrust fault which cuts diagonally into the limestone on the west side of the ridge has narrowed it to the south by cutting off part of the western limb of the anticline. On the west the Wappinger limestone has been thrust over on the slates. The relations along the eastern boundary of this belt are not clear; apparently the slates lie conformably on the limestone, but since the southwestern belt of Wappinger limestone, with which this northeastern one was formerly continuous, is separated from the slates on the east by a gravity fault, the same relations are thought to obtain here. Still less obvious are the structural conditions at the southern end of the unit at Balmville, where exceptionally thick drift mantles the bedrock. The location of the cross valley and the offset of the limestone ridge (this is visible on the geologic map) indicate a cross-fault, which dropped the northeastern block of limestone and shifted it slightly to the east.

The Southwestern belt of Wappinger limestone. A continuation of the belt just discussed, the belt of limestone underlying a large part of West Newburgh, is somewhat more complex structurally than the northern unit and is about three times as wide. The thrust fault that bounds it on the north swings far to the west north of Glenwood Park and makes the limestone belt there about 2 miles wide. Its northern boundary has been discussed as the southern limit of the limestone unit just described. On the east

[129]Gordon, C. E. *Loc. cit.* p. 55.

the contact between it and the Hudson River slates is a gravity fault to the north and a thrust fault to the south where the narrow wedge of crystallines intervenes. Over large areas of this belt glacial deposits conceal the bedrock, so that few outcrops are visible. From these, however, the limestone is seen to have responded in gentle open folds to the orogenic movements of the Paleozoic (see figure 2). Low marshy country between hills of limestone on the state road south of Glenwood Park indicates a fault, which is thought to continue to the southeast cutting across the Snake Hill inlier and lowering and offsetting its northern prong.

The Northwest Corner of the Quadrangle

The area in which the competent Shawangunk grit is practically the only bedrock is simpler structurally than any other part of the region under discussion. Having acted as a competent member in the Appalachian revolution, it is folded in shallow open folds, which pitch about 15° to the north and become lower to the west. In broad structure, therefore, the Shawangunk mountains are a west-dipping monocline interrupted by gentle undulations. Of more than usual importance as a larger feature are the two major joint systems, which are chiefly responsible for the steep cliffs, clefts and valleys. The directions of the main joints, north 20° east and north 60° west, are so striking in the adjoining Ellenville sheet that they stand out clearly on the topographic map of the quadrangle. Undermining of the conglomerate by removal of the soft slates beneath has caused the former to settle and the joints to open and become very broad, many being 7 to 8 feet across. Some of the joints extend 175 feet down into the solid conglomerate, which is so thick that in only one small area on the Newburgh sheet has it been breached. The underlying slates are thus exposed north of Lake Minnewaska between Beacon hill and Dickie Barre, on the anticline along the crest of which these features lie. In another direction, at an oblique angle to the strike of the folds, this isolated slate area, or fold inlier, is in alignment with Peterskill falls and the Trapps, the break in the Shawangunk front range through which the road ascends from the valley to the east. A joint or fault must account for the greater incision along this line.

ECONOMIC GEOLOGY

In rock products of economic significance the region of the Newburgh quadrangle is singularly poor.

For many years expectation was high that coal would be found in the blacker Hudson River beds; the dark color and the presence of small masses of anthracite were the lodestars. In Newpaltz, Plattekill and at numerous localities small masses of anthracite have been found, but in very small quantities and of no value whatever. Along the West Shore tracks east of Balmville is a hole in the slate cliff pointed out as the entrance to a coal mine. No one knows that any coal was ever discovered there, and there is no likelihood that any will be found, since the conditions for plant accumulation necessary for coal had not been reached at the time these beds were deposited.

Some of the more massive graywacke beds have been used for building stones, for which purpose they are well adapted; but beds massive enough are not abundant, whereas from the Catskills not far to the northwest come quantities of the bluestone, unsurpassed as building material. Other layers of the formation were used to a small extent in the construction of fireplaces and lining of furnaces. Placed with the edges of the laminae to the fire, the rock resists heat for some time. The greatest use of the Hudson River beds has been in the construction and repair of roads, and it is still largely used for this purpose. It is, however, very poor material for roads, since it is so easily reduced to powder by the wheels of vehicles which pass over the roads, and the dust is quickly swept away by rain and wind. Such road material must be renewed often; it is only because of the extremely low cost of quarrying and of the nearness of the source that the rock can be used at all.

A much more resistant road metal is that furnished by the drift which covers the whole district, especially the lower portions, to a greater or less thickness. From the thick delta-like deposits wagonloads of material are carted off to small crushers which are put up along the road to be improved. In this way boulders are crushed and used locally, or the finer material is dumped on the roads without being crushed at all. To a still more limited extent the Shawangunk grit also is used for road metal, but only locally in the mountains of the same name. One of the earliest industries in this part of the State was the cutting of grindstones from the more even-textured layers of the formation. The demand for grindstones made from this rock has practically ceased, however, and

there is only occasionally an order to fill. In the yard of many a farmhouse can be seen the discarded tool of former days.

The limestone in and about Newburgh was formerly burned for lime. This was never an industry of any extent, and is not carried on at all at present. West of the city of Newburgh on the state road to Montgomery are several abandoned kilns. From the limestone southwest of Newburgh building blocks were formerly quarried.

By far the most important of the geologic formations economically are the clays. These have been treated in great detail by Ries.[130]

The only clays of economic proportions in the district are those at Newpaltz. The brick yard of the Newpaltz Brick Company is located on the outskirts of the town near the Wallkill Valley Railroad with which it is connected by switch. The deposits of yellow, red and blue clays are from 15 to 50 feet thick and overlie a tract of 6 acres. The natural separation of the clay into 4 to 8-inch layers facilitates the digging of it, after a thin stratum of sand overlying the clay has first been stripped. The Lowe Brick Company, which manufactures 2,000,000 bricks a year, is working 20 feet of clay upon which the sand overburden is about 12 feet thick. It is estimated that the clay is 200 feet thick, the uppermost 4 to 5 feet being red clay. The pits are worked from May to October. Just beyond the eastern limits of the map are located extensive deposits of excellent clays that constitute some of the terraces along the Hudson river, as at Roseton, Danskammer and South Newburgh.

No discussion, however brief, of the economic geology of the quadrangle would be complete without reference to the Catskill aqueduct system[131] which supplies water for the millions in New York and which crosses the sheet diagonally from north to southeast. On the geologic map its course is marked by the heavy dotted line; in the field the line of the aqueduct is marked by low white fences and white posts along either side, and is distinguishable as a landmark at considerable distance. The aqueduct construction is of the cut-and-cover type, "essentially a great trench,

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[130] Ries, H. Clays of New York. N. Y. State Mus. Bul. 35, no. 7. 1900. p. 489–944.
The Quaternary Deposits of the Hudson River Valley between Croton and Albany, with Notes on the Brick Clays and the Manufacture of Brick. Tenth Annual Rep't State Geologist for 1890. p. 110–55.

[131] Berkey, C. P. Geology of the New York City (Catskill) Aqueduct. N. Y. State Mus. Bul. 146. 1911.

with a concrete floor and arched roof so that water will flow of its own accord slowly toward New York City."[132] In order to maintain the grade it was necessary in places to cut away the rock, and in others the fill in or raise the level of the surface. Practically all the cuts made for the aqueduct in the Newburgh area were in Hudson River shales, and for the fill many quarries were opened in the same formation. Plate 21 shows one of the larger of these cuts. Much information as to the habit and structure of the formation was gained in this manner.

Other economic products of the district are far more important than are those just mentioned. The soil of the area and its abundant water supply are the chief resources. Although the activity of the inhabitants is mainly agricultural, the soils are not especially favorable. A report on the soils of Orange county[133] gives in great detail the types and distribution of the soils and the present usage and crop possibilities of each and is accompanied by a very useful map. In common with most of northeastern United States, this section of land is suffering from impoverishment by the continental ice sheet, which in advancing scraped off all the residual soil that had covered the rock, and in retreating dropped a hummocky blanket of rocky soil over everything. Throughout the area in which the Hudson River formation constitutes the bedrock the soil is warm and mellow, for since the strata dip at a relatively high angle, the rock weathers back readily at the surface, allowing water to sink down between the impervious beds and keeping the soil from becoming cold and wet. The soil on the limestone is good; that on the Shawangunk conglomerate is cold and meager. All of the soil is rocky.

Dairying, farming and fruit growing are carried on very largely. Hay and corn, the chief crops, are those needed especially in the dairy industry. Butter and milk are produced in large quantities. Among the fruits raised are apples, pears, peaches, plums and all kinds of small fruits. Truck crops, especially onions, celery and lettuce, are also important. On account of the excellent shipping facilities, railroads and steamboat lines on the Hudson river, all of the farm products find a ready market in neighboring towns and cities and also in New York City which is reached by rail in 2 hours.

Many small mills are located along the swifter streams, as for

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[132] Berkey, C. P. The Water Supply of a Great City. Natural History, v. 20, no. 4. 1920. p. 406–21.

[133] Crabb, G. A. & Morrison, T. M. Soil Survey of Orange County, New York. U. S. Dep't of Agriculture, 14th Rep't. 1912. p. 57–108.

instance the grist mills along Shawangunk creek. Water power from the falls of the Wallkill at Walden is utilized by knife factories, one above and one below the falls. Quassaic creek which flows out of Orange lake through Newburgh to the Hudson, furnishes waterpower all along its course, and within the city of Newburgh several large factories are dependent upon its flow. From Peterskill falls electric power is now being developed for illumination of the hotels at Lake Minnewaska.

GEOLOGICAL HISTORY

Upon a basement of which we have no evidence in the area, and which may be thought of as part of the original crust of the earth, was laid down an immense thickness of sediments, probably sandstone, shale, and limestone, in more or less regular succession. These passed through every stage of metamorphism and injection, complexly repeated many times. They are correlated with the old metamorphic rocks of southeastern Canada and New York and are called Grenville. Uplifted above sea level later in Precambrian time, these hard resistant rocks became subject to the agents of erosion, to which they were exposed for an enormous period of time—time that sufficed for one of the most extensive levelings presupposed in the geologic history of the earth.

The earth movements that ended this period of erosion and ushered in the new era made changes in the extent of land and sea which were the determining factor in the subsequent history of the region; for the Hudson valley is part of the area included in the Appalachian geosyncline, the broad shallow trough, which during the Paleozoic era extended from the Gulf of Mexico northeast into Canada. It was bounded on the east by a mountainous continent, Appalachia, which was the source of the great thickness of clastic sediments deposited in the neighboring trough.

The sea in Lower Cambrian time advanced along the geosyncline upon the irregular basement of eroded Grenville rocks, covered by sands and pebbles of quartz. These the sea reworked, and made into the Poughquag or basal quartzite of southeastern New York. With continued advance of the sea there was deposited a thick limestone, which lies conformably upon the quartzite and in its lower portion is also of Lower Cambrian age. Evidence of a withdrawal of the sea at the close of Lower Cambrian is masked in the massive, nearly unfossiliferous limestone, and would not be known if it had not been detected in the extension of the rock into

neighboring areas. Deposition of limestone continued probably from Upper Cambrian into Middle Ordovician when another break occurred, marked this time by a limestone conglomerate. After the deposition of the limestone which marked the return of the sea there followed a time when quickened streams from Appalachia carried into the trough much land waste, so that in its eastern portion at least the water was too muddy for the formation of limestone. Upon the clear water lime muds, therefore, was deposited a considerable thickness of argillaceous mud and sands with some lime admixture. Swift, variable currents transported these materials, and heaped them helter-skelter in the ever-changing near-shore facies known as the Hudson River formation. In the comparatively shallow and rapidly moving waters in which the formation was accumulating lived many brachiopods, belonging, however, to a very few species, and some crinoids, bryozoa and graptolites. At time some parts of the trough even became dry land; for a coarse breccia containing fragments of many kinds of rock such as chert, limestone and shale, is developed in the midst of the heavy graywacke of the Marlboro mountains.

Toward the end of the Ordovician period the deposition of the clastic series was interrupted by the Taconic disturbance which by folding and uplift exposed these rocks to erosion, and shifted to the west the deeper portion of the trough in which deposition continued. Upon the new land surface, formerly the eastern portion of the trough, were piled coarse materials from the waste of the land to the east. Large streams, their gradient increased by relative uplift of Appalachia, dropped their loads at the foot of the mountain, either as delta fans in very shallow water, or as subaerial alluvial fans on the lately uncovered land. To the early Silurian, probably, belong these thick sandstones and conglomerates which are known as the Shawangunk formation, and which rest upon the upturned and eroded Hudson River beds. Except in a few occurrences of thin lenticles of finer textured material, no fossils are found in the Shawangunk and those that are found have no value for close correlation, because, aside from Arthrophycus alleghaniensis and several eurypterids, the fauna has no counterpart in the standard geological column. After shallow sea or continental conditions had prevailed for some time, the sea gradually returned from both the south and the north and with minor retreats covered this portion of the trough from Upper Silurian into Middle Devonian. Toward the end of the latter period continental conditions again obtained, and probably continued to the end of the Paleozoic. The evidence for

these steps is not to be found in the Newburgh quadrangle, but is deduced from evidences in surrounding districts, with which this area has held a common development.

The culmination of later Paleozoic instability, manifested in the repeated advances and retreats of the sea and uplifts of Appalachia, was a last great earth convulsion which folded and faulted the thick deposits of the geosyncline, the movements being dominated by thrust from the east. Uplifted considerably during the revolution and subjected to active erosion, the later Paleozoic deposits were quickly worn away, so that their absence does not disprove their former presence. Upon the surface, eroded by this time nearly to sea level, were laid down the clastic Triassic beds which were later injected by basic igneous sheets and then normally faulted and tilted in a manner typical of the period and the region. By this structure are recognized the deformations of the Palisadian disturbance. Residual masses of the Mesozoic rocks in New York State are very few, for by the end of Cretaceous time a relatively perfect peneplain extended over the whole of eastern United States. Remnants of this old surface are seen still in the tops of the Highlands and the even crest of the Shawangunk mountains. Uplift of the eroded surface was accompanied by gentle tilting toward the southeast and marked the opening of the Tertiary period.

It is doubtful whether any formations of this period are present or ever were present in the Hudson valley. Certain peculiar deflections of the Hudson river, where it left its former course and cut a new one for a short distance, thereby leaving a mass of stranded rock as an island in the river, may be considered evidence that Tertiary deposits once extended up the Hudson valley. By Middle Tertiary time, however, a very gently rolling plane had been eroded on the soft rock zones, an especially broad Tertiary peneplain belt being developed along the central part of the Hudson valley. Uplift at the end of the Tertiary caused renewed cutting by streams; from this period dates the gorge of the Hudson river below the Tertiary peneplain.

The great continental ice sheet covered the region during part of Pleistocene time, and rubbed off the tops and angles of the hills. Here near the close of the glacial period were long bays extending up between the melting ice lobes. Over the surface the retreating ice dropped much heterogeneous material, the ground moraine; the more sorted kame material was deposited in reentrant angles of the ice by water from the melting ice; the finest debris subglacial streams carried into the still water of the bays, where it very slowly settled in

beds of clay and fine sand. Slight submergence beneath the sea followed retreat of the ice sheet and allowed ocean water to flow into the Hudson river, making it an arm of the sea. Recovery from this submergence was only partial, and the Hudson river is still a drowned valley.

Modification of the topography during the recent period has been negligible. Postglacial streams with few exceptions have been unable to cut through the drift cover. The most notable postglacial changes are those made by man during his geologically short occupancy of the district. During this brief period he has bridged rivers, tunneled alike under rivers and mountains, and made use of almost every natural feature, even of the broad peneplain developed over the area during the Tertiary period. Along this gently rolling surface flows the water supply for Greater New York's millions, who have reason indeed to be thankful that the geologic history has been such as to permit the development of the broad, fertile, scenic valley of the Hudson river.

INDEX

Figure 7. Cross-section of the Wallkill Valley

LEGEND

Fault

Probable Fault

Catskill Aqueduct Pressure line

Cut-and-Cover line

Fossils

Conspicuous Outcrops in spots of deep color

FORMATIONS

Shawangunk

Hudson River (Snake Hill)

Wappinger

Poughquag

Precambrian

TOPOGRAPHY BY U. S. GEOLOGICAL SURVEY,
IN COOPERATION WITH THE STATE OF NEW YORK
1904-1905

APPROXIMATE MEAN DECLINATION 1903

Scale $\frac{1}{62500}$

Contour interval 20 feet.

Datum is mean sea level.

Geology by Florrie Holzwasser
1922

LEGEND

SEDIMENTARY ROCKS

PLEISTOCENE

Glacio-lacustrine sands
(Overprint where nature of underlying rock is uncertain.

CAMBRIAN

Cp — Potsdam sandstone

PRECAMBRIAN

Gv — Crystalline limestone *(Grenville series).*

Gvq — Crystalline limestone with intercalated white quartzite and siliceous beds. Grenville series.

MIXED ROCKS

Gnp — Pyroxene gneiss
(Metamorphosed calcarepus beds of Grenville formation, injected by pegmatite and syenite, and intruded by sheets of granite and syenite)

Gnr — Undivided gneisses
(Biotite, cordierite, garnet, sillimanite, and pyritous gneisses, members of Grenville formation, injected by pegmatite and modified by granitic juices).

Gng — Biotite-garnet gneiss
(Beds of Grenville formation in last stages of disintegration by pegmatite veins and granitic juices. Intimately involved with sheets of granite).

Gnb — Quartz-biotite gneiss
(Of doubtful origin).

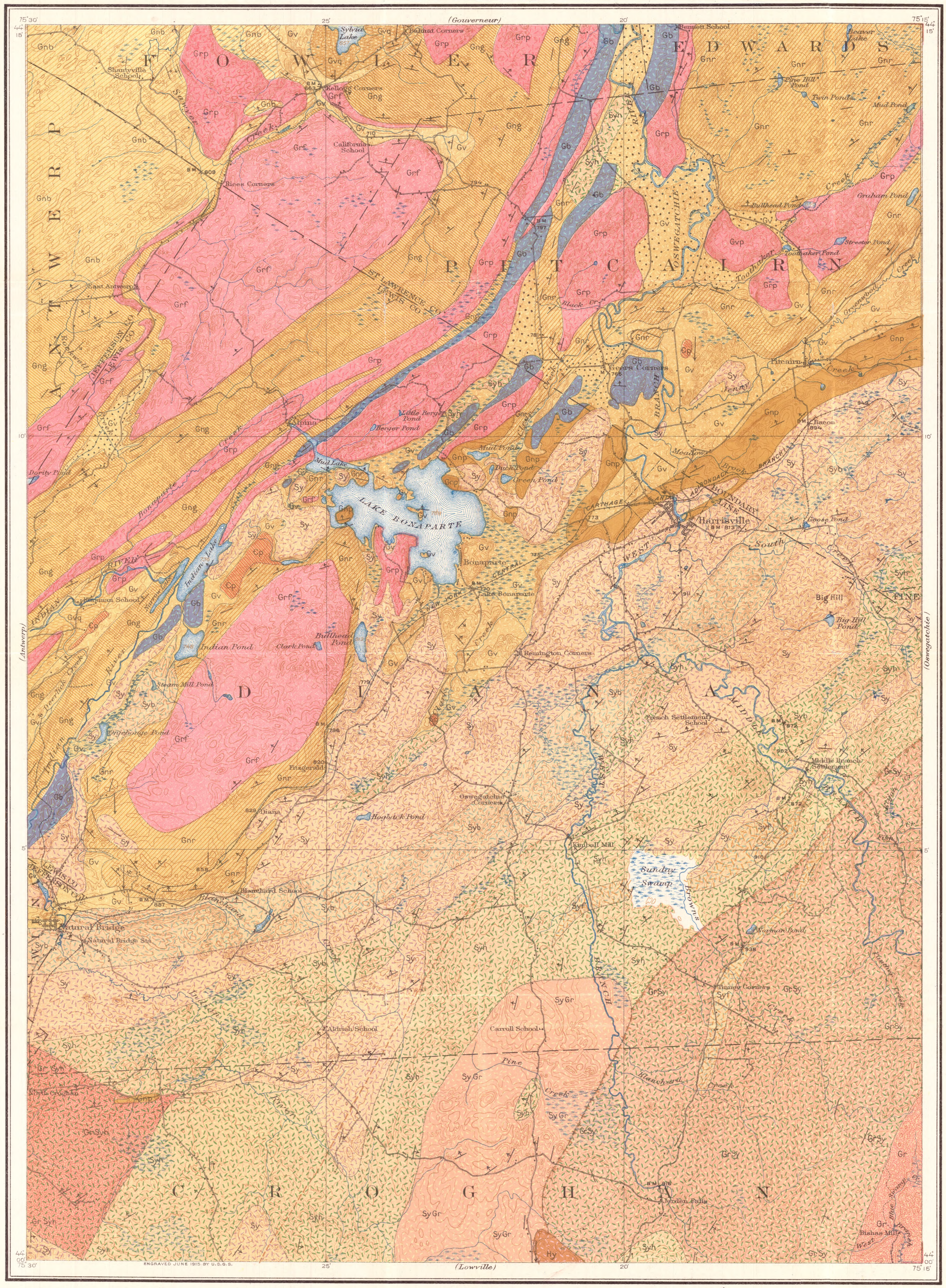
Strike and dip of foliation

Vertical Dip

Direction of glacial striae

Boundary line between gneisses of syenite-granite complex having a cataclastic protoclastic texture, on the NW., and gneisses having a protoclastic texture, on the SE.

Boundary line between gneisses with protoclastic texture on NW., and gneisses with interlocking texture of crystallization, on SE.



LEGEND

IGNEOUS ROCKS

PRECAMBRIAN

YOUNGER GRANITES

Grp — Granite gneiss
(Dominantly coarse porphyritic, may be medium grained near contacts).

Grf — Granite gneiss
(Usually fine grained, gneissic structure locally indistinct).

Hy — Hyperite
(Diabasic textured rock occurring as stocks, dikes, and sheets in syenite-granite complex).

MONZODIORITE-SYENITE-GRANITE COMPLEX

Gr — Granite gneiss
(Highly quartzose, equigranular hornblende-biotite rock).

Sy Gr — Grano-syenite gneiss
(Fine grained, equigranular).

Gr Sy — Hornblende-biotite Grano-syenite gneiss
(Medium grained, equigranular).

Gr Syh — Hornblende grano-syenite gneiss
(Coarsely porphyritic).

Syh — Hornblende syenite gneiss
(Coarsely porphyritic red gneiss).

Sy — Augite syenite gneiss
(Coarsely porphyritic in main body, equigranular in masses intrusive into Grenville).

Syb — Basic augite syenite gneiss
(Coarsely porphyritic in main body, equigranular, south of Indian Pond, in part monzodiorite).

Syf — Augite-hypersthene syenite gneiss
(Coarsely porphyritic).

Gb — Gabbro amphibolite

TOPOGRAPHY BY U. S. GEOLOGICAL SURVEY, IN COOPERATION WITH THE STATE OF NEW YORK
1904-1905

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.
Datum is mean sea level.

APPROXIMATE MEAN DECLINATION 1912.

Geology by A. F. Buddington,
1916